THE SCIENTIFIC MONTHLY

VOL. LXV *August 1947* NO. 2

WILLARD LEE VALENTINE, 1904–1947

By DAEL WOLFLE

Executive Secretary, American Psychological Association, Washington, D. C.

WILLARD LEE VALENTINE, Editor of *Science*, died unexpectedly at his home in Alexandria, Va., on April 5, 1947. Sudden heart failure ended his career at the age of forty-two.

Dr. Valentine was born December 2, 1904, in Chillicothe, Ohio. There he received his elementary and high-school education. He attended Ohio Wesleyan University and received the A.B. degree in 1925. That summer he served as an assistant at the Munsell Color Research Laboratory in Baltimore. In the autumn he returned to Ohio Wesleyan as an assistant in mathematics and psychology. The following year he was promoted to the rank of instructor in psychology, a position he held for the next two years while continuing his graduate study under Professor F. C. Dockeray. In 1928 he moved to The Ohio State University. He and I were both new graduate students there that fall, and we had adjoining offices. In common with students everywhere, we enjoyed trying to reconcile our different viewpoints.

Under the direction of Professor A. P. Weiss he completed his graduate work that same year and received the Ph.D. in 1929. Ohio State Ph.D.'s were rarely retained on the permanent teaching staff, but Valentine was an exception. He was offered, and accepted, an assistant professorship. The year before, as a graduate student instructor, he had taught some of the small groups of beginning psychology students; now he assisted in directing the group of student instructors.

In addition to his purely administrative duties at Ohio State, Valentine prepared instructional materials to encourage similarity in the many introductory psychology classes. First he wrote an experimental laboratory manual, which went through several revisions as experience dictated changes and improvements. *Readings in Experimental Psychology* (Harpers 1931) was a first effort to prepare a collection of research reports that would introduce the beginning student to some of the active research problems in psychology and teach him the methods used to solve those problems. *Experimental Foundations of General Psychology* (Farrar and Rinehart, 1938, revised edition 1941) was a later and much improved collection of research papers prepared for the same purpose. Most of the papers in the first volume were rewritten by Valentine, not to write them down, but to write them for the elementary student. Four were original papers. As the author

WILLARD L. VALENTINE, 1904–1947

of one of the four, I noted with interest that Valentine rewrote everything in the later book. That was an improvement; the four original articles were much more difficult for students to comprehend than were the parts that had been rewritten.

Both books, and particularly the later one, found a wide usefulness in classes in many colleges and universities other than Ohio State. At the time of his death Valentine had returned to this early interest in making better teaching materials available; he had just completed a third edition of *Experimental Foundations of General Psychology*.

Dr. Valentine's research centered in the field of learning. Studies at Ohio Wesleyan were based on experiments in animal learning. His doctoral dissertation dealt with a problem in human learning. Post-doctoral research at Ohio State was in the field of infant behavior, where he was one of the collaborating group organized around Professor Weiss. During these days he developed an interest in motion-picture records of infant development. He was

concerned with theoretical as well as purely experimental problems in learning and contributed to the literature on mathematical characteristics of the learning curve.

Ohio State University promoted him from assistant professor to associate professor in 1932. In 1940 he moved to Northwestern University as professor of psychology and chairman of the department, a position he held until the autumn of 1945.

In 1937 Valentine was chosen as treasurer of the American Psychological Association. A year later he became business manager of the Association's publications. At that time the APA published five journals, with a combined total circulation of about 5,500 subscriptions. Between 1938 and 1945, when he resigned as business manager of publications for the APA, several new journals were added to the list, club-rate subscriptions were made available to members, and the total circulation grew to approximately 19,000 subscriptions.

At a meeting of the Board of Directors of the American Psychological Association held just a week before he died, Valentine asked for the privilege of resigning from the position of treasurer. The directors persuaded him to serve out the remainder of his term, which would have expired in 1950. He had for ten years been the Association's central figure in financial planning; the directors did not wish to lose his knowledge and counsel.

Valentine's editorial skill, coupled with his years of successful management of psychological publications, made him a logical choice for the editorship of *Science* when the American Association for the Advancement of Science assumed active control of that journal. He was offered the editorship in the fall of 1945. Northwestern University consented to his release, and in November he moved to Washington to begin planning his first issue of *Science*. He believed that *Science* had been too technical in its content, that it ought not to have the same type of content or the same function as a specialized scientific journal, and that it ought to contain material about science and scientists that would be of interest whether the reader was a chemist, a zoologist, or an anthropologist. He sought to remake it into a newsweekly of general scientific interest. In that effort he was achieving gradually increasing success until the time of his death. News items about scientists had become a more prominent feature, and articles of a general nature were more common. During 1946 and again in 1947 when Science Foundation bills were being considered in Congress, scientists were kept informed of their nature and progress through the pages of *Science*. Other legislation affecting scientists was summarized. Together with these changes in content went an improved and more readable format. At the end of his first year as editor, Valentine conducted a readership survey of a selected sample of *Science* readers. The result must have been very satisfying, for there were many favorable comments; he also received fan mail in substantial amounts.

Valentine's professional life consisted very largely of a life of service to his fellow psychologists. His books, his years of assistance to younger instructors at Ohio State and Northwestern, his work as treasurer of the American Psychological Association, and his management of the APA publications made him one of the most respected of American psychologists. When his ability was recognized outside psychology he moved into a position of larger opportunity for service to scientists of all fields. Death came in his prime, depriving science of an able worker and scientists of a valued friend.

SCIENTIFIC EDUCATION FOR AIR FORCE OFFICERS

By CLARENCE R. WYLIE, JR.

Since August 1947 marks the fortieth anniversary of the establishment of the precursor of the Army Air Forces, we called upon Professor Wylie to review the growth of scientific education of AAF officers within the army and in particular to describe the new AAF Institute of Technology at Wright Field, of which he is Acting Dean of the College of Engineering Sciences and Chairman of the Department of Mathematics. Dr. Wylie (Ph.D., Cornell, 1934), formerly Assistant Professor of Mathematics at Ohio State, served in the Propeller Laboratory at Wright Field during the war. Also a poet, his "In Memoriam" to General Gross appears on page 102 of this issue.—Ed.

ON September 3, 1946, when Lieutenant General Nathan F. Twining, Commanding General, Air Materiel Command, officially opened the Army Air Forces Institute of Technology with his address of welcome to its first class, the fourth stage in the evolution of scientific education within the AAF began. For 33 of the 40 years that have elapsed since the modest beginning of the AAF with the detailing of two enlisted men to aeronautical duty in June 1907 and the creation of an aeronautical division in the office of the Chief Signal Officer of the United States Army in August 1907, this program of scientific instruction has paralleled in its development the growth of the Air Force itself. The problems of one have been the problems of the other; the triumphs of one have been, in part, triumphs of the other; and the future of the Air Forces as a guarantor of national security and peace is in ever-increasing measure a matter of maintaining technical leadership through officer training such as that provided by the AAF Institute of Technology.

In 1907, nine years after the inception of the subsidized experiments of Professor Langley and four years after the Wright brothers' first successful flight at Kittyhawk, the great problem confronting the air-minded leaders of the United States Army was still that of getting a plane that would fly. Not until August 1909 when the Wrights delivered a plane which met the requirements of carrying two passengers and flying 125 miles at a top speed of 40 miles per hour was this first problem successfully solved. For the next several years all the energies of the youthful aeronautical division were concentrated on learning to fly, and training in the scientific aspects of aviation was not undertaken until 1914, when Captain Virginius E. Clark was sent to M.I.T. to study aeronautical engineering. This first phase in the evolution of scientific education of Air Force officers was further expanded during World War I; and, paralleling the much larger training programs for flyers, mechanics, and supply officers, a course in aeronautical engineering for army and naval personnel was established at M.I.T. in 1917. From this two small classes were graduated.

In 1918, as combat experience made it increasingly clear that the military usefulness of airplanes extended far beyond the functions of observation and reconnaissance, the air activities of the army were detached from the Signal Corps; and a Department of Military Aeronautics and a Bureau of Aircraft Production were established. In this period of reorganization and change the second stage in the Air Force's program of technological education was begun. At the suggestion of Colonel Thurman H. Bane and upon approval by the War Department, a School of Aeronautical Engineering within the army,

known as the Air School of Application, was established in 1919 at McCook Field, the army's new research and development center at Dayton, Ohio. The first class, which entered in November of 1919, consisted of but seven officers. When Congress created the Air Service in 1920 by consolidating the Department of Military Aeronautics and the Bureau of Aircraft Production, the name of the school became, quite naturally, the Air Service Engineering School.

Until the creation of the Institute of Technology, the course of instruction in the Engineering School was of a year's duration. Entrance requirements were very flexible; and although graduates of West Point, Annapolis, or recognized civilian colleges were preferred, it was possible for an officer to enter with only a high-school education, provided that by experience and personal study he had mastered the fundamental engineering sciences of mathematics, physics, mechanics, chemistry, and drafting.

Originally, to quote an early bulletin,

> The school was opened for the purpose of giving instruction to senior officers in the Army Air Service holding important posts of command in order to keep them up to date on aircraft developments and to make them more efficient in the administration of their various stations. In other words, this school attempts to bridge the gap between the technical and the non-technical officer.

The major divisions of the curriculum were:

Mechanics, Strength of Materials, and Materials Laboratory
Shop Work
Business Administration
Armament
Electricity
Thermodynamics and Engine Design
Theoretical Aviation and Airplane Design

In general, the courses were taken consecutively rather than concurrently, each subject being studied intensively for a relatively short period. The method of instruction was "applicatory;" that is, it consisted of student projects initiated and completed with a minimum of formal lecturing. There was no permanent faculty, and, instead, all the specialists of the Engineering Division of McCook Field, of which the Commandant of the School was also the Commanding officer, were what might be called consulting instructors.

The second epoch in the development leading to the AAF Institute of Technology ended in 1926 when Congress authorized the creation of the Air Corps and an accompanying five-year program.

At this time McCook Field was relocated on a larger and more suitable site donated by the businessmen of Dayton, and its name was changed to its present designation—Wright Field. The Air Service Engineering School now became the Air Corps Engineering School. Although the latter retained the one-year course and the general curriculum of the former, there were certain fundamental changes in philosophy and policy motivated by the increasing importance of science and the specialist in the development of air power. The original purpose of educating senior officers holding command positions was enlarged to include the training of younger men to fill positions in research and design within the Engineering Division. The theory of instruction was correspondingly modified. Increased use of the lecture method was begun, and the first step in the creation of a permanent civilian faculty was taken with the appointment of Ezra Kotcher, now Director of the AAF Institute of Technology, as senior instructor. In this new direction the school continued without interruption except for the years 1927–28 and 1939–40, until Pearl Harbor, when more urgent needs for trained personnel forced a suspension of classes until 1944.

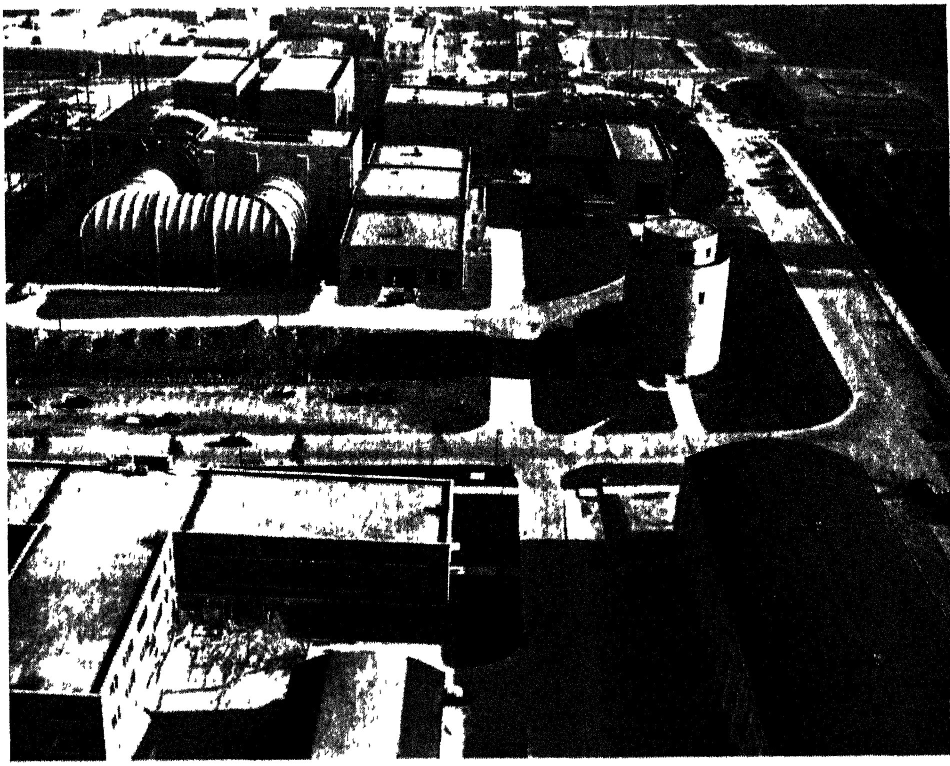
When the school was reopened, with the

name AAF Engineering School, in April 1944, the need for scientific leadership was so great that a year's course was a luxury that could not be afforded, and the efforts of the school until the end of the third phase of its development in 1946 were restricted to short-term refresher work in mathematics, mechanics, thermodynamics, and aerodynamics for men who were already engineering graduates.

MEASURED by the number of graduates from 1919 to 1946, the educational venture that has culminated in the AAF Institute of Technology has had only a limited success. Including graduates of the three- and six-month courses of 1944–46, 394 officers in all have received training. The achievement of its graduates is the proper measure of a school, however, and by this criterion the Institute of Technology inherits a tradition of which any institution might be proud. General Kenny was a graduate of the class of 1921, and General Doolittle a graduate of the class of 1923. General Chidlaw, director of all engineering research and development at Wright Field, and General Craigie, present chief of the Engineering Division of the Air Materiel Command, are also graduates. General Fairchild, present Commandant of the Air University, and General Gross, first Commandant of the Institute of Technology, were trained in the school. Other leaders of the AAF to whose professional development the school made its contribution included General Powers, General Whitehead, General Echols, and many more.

Inspired by the record of the Engineering School in training such men as these and conscious of the vastly greater need for leaders of similar technical competence in the future, the Commanding General of the Air Materiel Command in 1945 appointed a board of officers to investigate the problem of creating at Wright Field a technical institute to provide Air Force officers with advanced training in aeronautical engineering and related subjects as applied specifically to AAF problems. The work of this committee was reviewed and extended by a group of civilian scientists known as the Markham Committee: John R. Markham, Massachusetts Institute of Technology; William H. Pickering, California Institute of Technology; E. E. Scohler, California Institute of Technology; and T. H. Troller, Case School of Applied Science. The recommendations of this board called for a school to provide the AAF with a minimum of 200 technical graduates a year. Officers were to be trained not only in aeronautical engineering and the supporting sciences, but also in the field of business administration and logistics as applied to the supply and procurement problems of the AAF. The curricula were to be patterned, with necessary modifications to fit them to the needs of the AAF, after the aeronautical engineering and industrial administration courses of the leading civilian universities. Courses were, in general, to be offered by a faculty composed chiefly of civilian scholars who were to be not only thoroughly competent scientists but professional teachers as well. In order to give stability and continuity to the instructional program, it was recommended that the appointments of faculty members carry the same implication of permanent tenure that accompanies appointments in civilian institutions.

This reorganization of the engineering school coincided with an even more important and more far-reaching reorganization of the entire educational program of the Air Forces. For 1945 saw all the high-level educational ventures of the AAF integrated into what is now known officially as the Air University Command with headquarters at Maxwell Field, Ala. Thus when the AAF Institute of Technology was officially activated in 1946, although for obvious reasons it was de-



AIR VIEW AT WRIGHT FIELD

SHOWING THE TWENTY-FOOT WIND TUNNEL, PART OF THE CAMPUS OF AAF INSTITUTE OF TECHNOLOGY.

tached from Maxwell Field and assigned to the Materiel Command at Wright Field, it appeared as one of six schools composing the Air University, ranking with the Air Command and Staff School, The Special Staff School, the Air Tactical School, and the School of Aviation Medicine as a supporting school of the all-important Air War College. Under the broad educational program projected for the AAF, qualified officers will normally alternate periods of active duty with periods of study in one or another of these schools.

The immediate direction of the Institute of Technology was entrusted to Brigadier General Mervin E. Gross, a graduate of the class of 1933 of the Air Corps Engineering School, who was appointed Commandant, and to Ezra Kotcher, the senior instructor in the Engineering School from 1926 until Pearl Harbor, who was named Director. During the war Professor Kotcher, as a major in the AAF, was actively engaged in research and development projects in guided missiles and jet aircraft. Following General Gross's death in a P-80 crash in October 1946, Brigadier General Edgar P. Sorensen, who was Assistant Commandant of the Engineering School from 1926 to 1930 and more recently senior Air Force representative on the Army-Navy Munitions Board, became Commandant.

Following the recommendations of the Markham Committee, the Institute consists of a College of Engineering Sciences, of which Dr. Clarence R. Wylie, Jr., formerly of The Ohio State University and now Chairman of the Department of Mathematics of the Institute, is Acting Dean; and a College of Industrial and Engineering

Air Materiel Command Photo

BRIG GENERAL EDGAR P. SORENSEN

COMMANDANT AAF INSTITUTE OF TECHNOLOGY.

Administration, of which Weldon B. Gibson is Dean. Dean Gibson was a member of the original board of officers that recommended the establishment of the Institute and during the war, as a colonel in the Air Corps, was in charge of requirements for spare parts, supplies, and equipment at the Air Materiel Command.

The faculty consists at present of 18 civilians and 6 officers. The civilian professors are for the most part former university professors who, by temperament and experience, are qualified to apply their knowledge to the practical problems of the AAF. Some were in uniform during the war and acquired their understanding of the technical needs of the Air Forces through their work as officers on engineering projects. Others served as civilian specialists in government laboratories, while still others worked as engineers for aircraft companies. The officers who are currently engaged in instructional work are all young men recently back from graduate school where they were sent under army auspices for advanced training in specialized fields. They are all well-qualified and enthusiastic lecturers and, although subject to the uncertainties of reassignment, are a welcome source of assistance during the growing period of the Institute.

In addition to the faculty proper, the specialists of the Air Materiel Command constitute an invaluable reservoir of instructional talent. Numerous special lectures and a few entire courses have already been presented by men not actually affiliated with the Institute, who have been released from a portion of their other duties to undertake such teaching. In return, faculty members of the Institute are from time to time called upon as consultants on problems in their special fields by engineers of the Materiel Command. In this way the choice of Wright Field as a location uniquely suited both to the needs and to the potential contributions of the Institute is justified, and host and guest alike are the richer. In the future, as the throes of organization and growth are left behind and a stabilized program emerges, it is contemplated that to an increasing extent the staff members of the Institute will interest themselves as specialists in the problems of Air Materiel Command and that correspondingly the superb experimental facilities of Wright Field will become available for faculty research. As a first step in this direction, the teaching schedules of the Institute already provide for a three-month period each year when a man will be relieved of teaching duties and, after taking his normal civil service vacation, will be able to spend at least two months in independent study and research, writing, or consulting work in one of the Wright Field laboratories.

THE curricula of the Institute, which now cover two years of work, each divided into four terms, have been constructed to be broad in scope and rich in fundamentals with a realistic understanding that it is impossible for an army officer to function as

a creative research scientist. The future of American military aviation requires not that military personnel undertake to make the scientific discoveries that must be made in order to maintain and advance our position of pre-eminence as an air power, but rather that they be able to sense in the pure research of civilian scientists elements of potential military value and that they be able to initiate, to direct, and to administer programs of research and development designed to exploit the military worth of such discoveries.

Air Materiel Command Photo

CLARENCE R. WYLIE, JR.

ACTING DEAN, COLLEGE OF ENGINEERING SCIENCES, AND CHAIRMAN, DEPT OF MATHEMATICS, AAFIT.

For this reason, the engineering curriculum of the Institute lays almost equal stress on advanced mathematics, mechanics, electrical engineering and electronics, thermodynamics, aerodynamics, and the application of all these to problems of design. To round out this work student officers in engineering also take occasional courses in war economics, industrial management, and procurement and supply. Students in the college of administration get an equally broad training in accounting and finance, economics, management, production, procurement and supply, and law and, in addition, are required to take drafting and basic courses in all the engineering fields listed above except designing. Electives in both colleges are strictly limited.

Air Materiel Command Photo

EZRA KOTCHER, DIRECTOR, AAFIT

The academic qualifications for admission to the Institute remain quite flexible. Basically, a man is required to have the mastery of mathematics, physics, chemistry, and drafting normally attained in the first two years of a standard engineering course. For students of administration, a proficiency in these same subjects, although on a lower level, is demanded, with economics or an equivalent business subject replacing drafting as a requirement. In general, a liberal policy of evaluating service experience, training obtained in army schools and correspondence courses, such as USAFI, and in granting entrance credit

Air Materiel Command Photo

WELDON B. GIBSON

DEAN, COLLEGE OF INDUSTRIAL AND ENGINEERING ADMINISTRATION, AAFIT.

through examination has been adopted.

Although the ultimate goal of the Institute is to conduct its instruction (after a necessary minimum of review) entirely at the graduate level, somewhat after the pattern of the Naval Postgraduate School[1], it is both necessary and desirable that young officers whose undergraduate work was interrupted or deferred by the war should be given every opportunity to complete their formal education. Provisions have been made for officers who are accepted for the regular army to return to their original schools and complete the requirements for their degrees. Many of these men, especially those whose early work was not along engineering lines, prefer training in the Institute in actual contact with AAF problems, however.

[1] Cf. Root, R. E Mathematics and Mechanics in the Postgraduate School at Annapolis. *The Amer. Math. Monthly*, April 1943, 238.

As a result of this state of affairs, the 181 officers in the present class of the Institute form a highly heterogeneous group. In rank they range from lieutenants to colonels; in age they range from twenty-two to forty-five. In educational background they range from men with little more than a year of college to men who already possess a degree. In each college a few well-qualified members of the latter group were permitted to enroll in a special one-year course and will graduate this month. The vast majority, graduates and nongraduates alike, are enrolled in the two-year course, however.

The number of students without degrees emphasizes one of the persistent and as yet unsolved problems of the Institute: Shall the curricula be organized in such a way that authority to grant degrees to men completing them can appropriately be sought? Officers whose education was disrupted by the war quite naturally desire a degree to mark their achievement in the Institute. On the other hand, in terms of the specific objective of increasing the technical competence of officers of the AAF, many subjects, especially those with a liberal or cultural character, that would have to be in any curriculum worthy of a recognized or accredited degree seem irrelevant and unjustifiable in terms of the time and faculty required for their presentation. At present it seems desirable to compromise between these two extremes by planning the curricula and establishing entrance requirements with the needs of the AAF for scientific personnel the only consideration, but at the same time making provision for conferring degrees upon those members of each graduating class whose work in the Institute, together with the work of college caliber done elsewhere, equals in amount, variety, and quality the proper requirements for a degree. Under such a plan, not all student officers would be candidates for a degree, for entrance

requirements would be based solely upon qualifications necessary for successful work in the Institute and not upon the additional subjects required for a degree but not offered in the school. To such men a degree might, perhaps, be granted at a later date if, through further study in civilian colleges near which they happen to be stationed, their deficiencies be removed. At present, no authority to grant any degrees is vested in the Institute.

Among other problems which have yet to be completely solved is the matter of basic laboratories. It is strange, perhaps, but true that, although the AAF Institute of Technology is located in the greatest aeronautical laboratory in the world, the acquisition of elementary laboratory facilities has been one of its chief concerns. For instructional purposes in basic courses in physics, electrical engineering, and materials testing, the elaborate and specialized equipment to be found in the Wright Field laboratories, even if it could be made available to the large groups involved, is quite useless. As a result, the Institute, like many another scientific institution, has found it necessary to create its basic laboratories *ab ova*, as it were. At more advanced levels, where existing equipment is relevant to course content, the problem of making it available at the proper time to the appropriate classes without completely disrupting experimental work actually in progress requires a tremendous amount of planning and cooperation between the Institute and the various laboratories of the Engineering Division. At present it is contemplated that the summer quarter of each year will be devoted to professional work in the Wright Field laboratories and that high-level laboratory work will be accomplished through full-time participation in the scheduled experimental work of the Air Materiel Command.

In addition to its primary instructional objective, the Institute of Technology has several other important functions to perform. Under a delegation of authority from the Air University, the Graduate Section of the Institute has the responsibility of administering specialized graduate training of AAF officers in civilian universities. This includes the screening of applicants for such studies and the monitoring of their progress in the institutions to which they are assigned. At present about 250 officers are pursuing graduate studies in technical fields of special importance to the AAF. Many of the country's leading engineering schools are participating in this program. In most cases, the universities simply admit the officers to their regularly scheduled graduate classes. In some cases, notably at the University of Michigan, where a course in guided missiles based on restricted material furnished by the AAF was created, an entire curriculum open only to army officers has been established.

A second function of the Graduate Section is the administration of the AMC Civilian Graduate Center. This is a cooperative educational venture with The Ohio State University through its Twilight School. Using Institute classrooms and office space, Ohio State presents selected graduate courses in the engineering sciences, business administration, and psychology. These are open to all properly qualified civilian and military employees of the Air Materiel Command and are designed to enable AMC personnel to secure masters' degrees if they so desire. In general, courses are presented by members of the faculty of Ohio State, temporarily resident in Dayton, although engineers from Wright Field and professors from nearby colleges, including the Institute, have on occasion been retained to offer particular courses.

Somewhat less developed but potentially of great value is the program of the Extension Section of the Institute. As its name suggests, the Extension Section is engaged in preparing technical correspondence-type

courses to supplement the training of National Guard and organized Reserve Corps officers. These courses, which are offered through the Air University, are designed to keep officers not on active duty abreast of important developments in the scientific aspects of air warfare.

With the creation of the Air University and the AAF Institute of Technology higher education within the Air Forces can be said to have reached its majority. Whether graduates of future classes will be able to cope as successfully with the problems of the "atomic age" or the "supersonic age" as their predecessors did with the problems of the "great beginning," time alone will reveal. The desire to keep America strong and safe is as great an incentive as ever to faculty and students alike; and although we cannot agree with the unknown chronicler of the old Engineering School who wrote in the early twenties, "There certainly is nothing more valuable than the realization on the part of a student that practically all knowledge has been laid down in written books and that this can be obtained by the student by a personal application," we shall strive to teach our graduates after they have mastered some of the knowledge "laid down in books" to encourage, to appraise correctly, and to apply fruitfully to the problems of national security the new knowledge to be found beyond their texts.

IN MEMORIAM

Brigadier General Mervin E. Gross

His wings are folded now. He lies asleep
Beneath the sky he loved and sought to make
A second highway for the needs of men.
Speak it majestically, that dream of dreams,
Mark how it made him fellow to the brave
Who in all ages, heedless of themselves
Or of their fate, choose as their cause the one
Most worthy of their daring and their strength.

His wings are folded, and we mourn his loss.
Yet are we certain that beyond our own
A wider sky awaits his venturing,
As here, because we knew him, worked with him,
And saw our common future through his eyes,
We have a greater goal toward which to press.

Clarence R. Wylie, Jr.

CRUMBLING ROCKS

By RAYMOND E. JANSSEN

Professor Janssen (Ph.D., Chicago, 1939) is head of the Department of Geology, Marshall College. Long interested in the popularization of science, he has written numerous books and articles in this field. He has designed geological exhibits for the Chicago Natural History Museum, the Chicago Century of Progress Exposition, Rosenwald Museum of Science and Industry, and the Texas Centennial Exposition. His research has been in paleobotany.

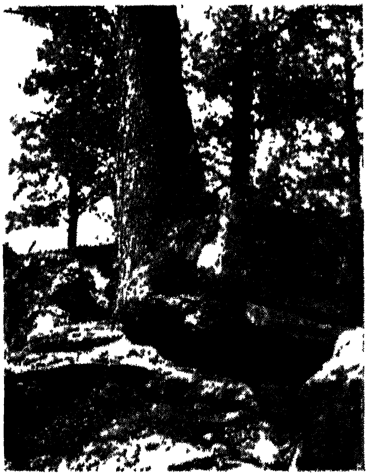
For the mountains shall depart, and the hills be removed.—Isa. 54:10

PROBABLY there is nothing in nature more grand and imposing than a lofty mountain, its towering peak snow-capped and glistening like a diadem in the sunlight, its enormous bulk fashioned from massive, solid rock. By contrast, nothing else on earth seems to be more firm and stable. It is not surprising, therefore, that such vistas have been an inspiration for poets, authors, and prophets throughout the ages. We find numerous references, particularly in the Bible, to the everlasting qualities of the hills and the mountains. The ancient prophets exalted their God by comparisons of his strength and endurance with those of the rocks and the mountains; they admonished the people that his steadfastness was even greater than that of these eternal structures. Even in modern parlance there are numerous sayings to the effect that something is "as old as the hills" or "as hard as a rock."

On the other hand, if one will pause to think a moment, it is self-evident that even the hardest rocks are subject to breakdown and decay. There are various examples of this on every hand. Inscriptions on old tombstones are slowly obliterated after many decades; surfaces of old stone edifices crumble away; stone steps of public buildings are gradually hollowed out by the constant tread of leather soles. Along country roads where the highway has been cut through rock strata, the stone soon loses its appearance of freshness, pitted surfaces develop, and pieces of rock slough off to collect in heaps at the base. If changes such as these occur within a few years or decades, infinitely greater ones must take place over periods of thousands or millions of years.

Detailed study of such phenomena has shown that over long periods of time all rocks exposed at the earth's surface are readily altered. For the most part, these changes are accomplished, directly or indirectly, by the action of the atmosphere and precipitation, and hence are appropriately termed rock-weathering. Depending upon the prevailing weather and climate and kind of rock in any given region, the alteration process may be dominantly chemical, mechanical, or a combination of both. In humid regions the rock surfaces become dull and stained, crumbly and pitted, as a result of chemical action of the moisture upon the minerals comprising the rocks, causing the latter literally to decay or decompose. It is this same process that causes old tin cans or the unpainted surfaces of bridges and other structures to flake off in the form of rust. In arid regions, on the other hand, the surfaces of the rocks may remain reasonably fresh, but cracks and fissures appear, and thin slivers and shells break away from the surfaces. Because here the air is relatively dry, the process is essentially mechanical in nature. Both processes, however, are forms of rock-weathering.

As a result of either of these processes or both of them, solid and firm rock ultimately crumbles into small pieces, grains, and dust. If the exposed rock forms the side of a cliff, steep valley, or mountainside, the weathered



Photos by author

WEATHERING AND EROSION

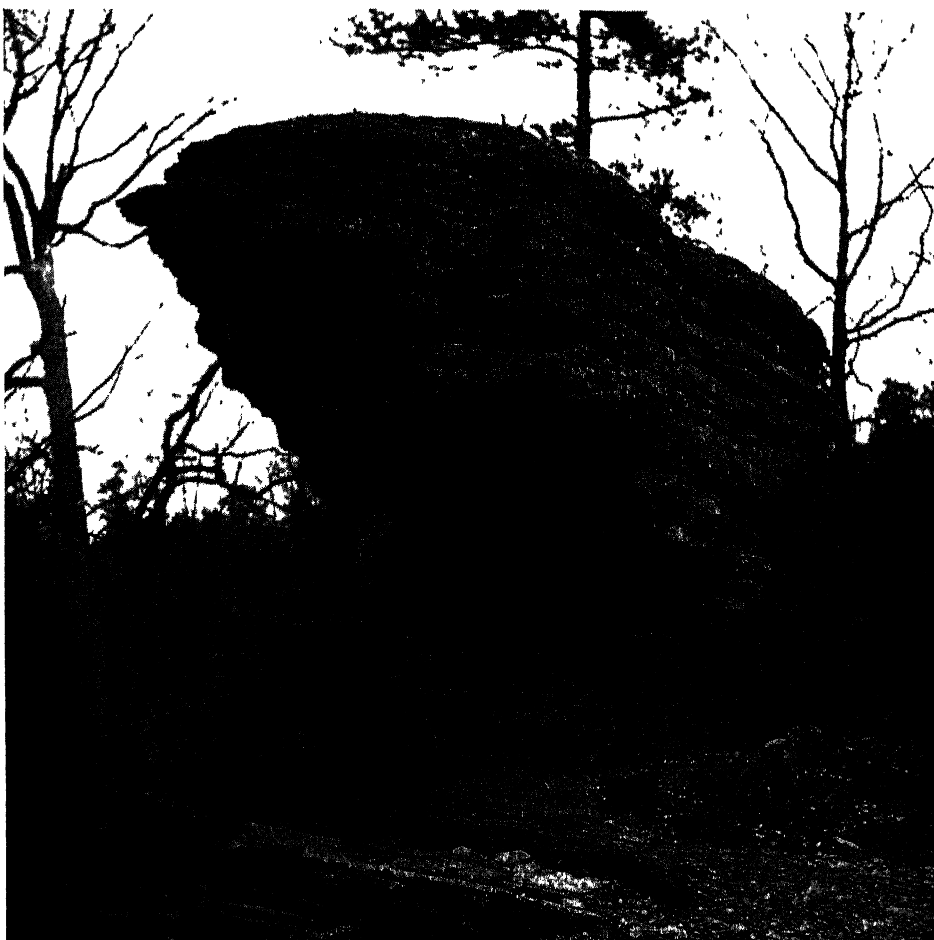
Upper left, EARLY STAGES OF WEATHERING AND EROSION ARE SHOWN BY THIS GREAT SLAB OF RIPPLE-MARKED SANDSTONE WHICH HAS FALLEN FROM A CLIFF NEAR ASHLAND, KY. *Upper right*, SERIOUS DEVELOPMENT OF EROSION IN SOIL MANTLE ON CUT-OVER HILLSIDE NEAR HUNTINGTON, W. VA. *Lower left*, ENORMOUS TRANSPORTING POWER OF GLACIAL ICE IS INDICATED BY THIS GREAT BOULDER WHICH WAS MOVED UPHILL FROM ITS ORIGINAL POSITION ABOUT 20 MILES AWAY IN YELLOWSTONE NATIONAL PARK. *Lower right*, GROWING ROOTS OF AN OAK TREE PRYING UP A SLAB OF ROCK IN THE OZARKS OF MISSOURI.

and loosened fragments slide or creep downgrade to build up heaps of debris, called talus, at the base of the parent rock mass. In some mountainous regions such heaps of slide-rock finally become so great as to bury the whole mountainside. If the bedrock is only gently inclined or essentially horizontal, the small fragments remain scattered on the surface, eventually weathering into smaller and smaller particles to form the mantle of soil that characteristically covers extensive areas of the earth's surface. In any region where soil lies on the surface, observation shows that with depth it grades downward into coarser and coarser fragments until the parent bedrock is reached. Such depths may, in various regions, be a matter of only a few inches or of hundreds of feet.

Because this mantle of broken rock and soil consists of relatively small particles, it is readily carried away by such mechanical forces as wind, running water, or ice, giving

rise to the familiar phenomenon known as erosion. Thus rock-weathering and erosion operate hand in hand to break down the solid rock and carry it away bit by bit to lower levels and finally to the sea. Through these combined processes, operating continuously through the ages, mountains are worn low and continental areas of past times have been literally washed away. Geologically, such events are of little moment in themselves because new lands and new mountains have continually been rebuilt or re-elevated from time to time to take the place of those that have been destroyed. From the human viewpoint, however, rock-weathering and the resulting erosion are of tremendous consequence, particularly where agriculture and related industries depend upon the use of the soil.

In nature, rock-weathering and erosion more or less keep pace with each other, thereby insuring retention of the soil mantle in regions where it has been developed. Here ground water and air, penetrating down-



Gray Brothers photo

UNEQUAL RESISTANCE OF ROCK STRATA

IN HUMID REGIONS SUCH CURIOUS FORMATIONS RESULT FROM OVERLYING ROCK LAYERS BEING MORE RESISTANT TO WEATHERING THAN THE LOWER ONES. NEAR EUREKA SPRINGS, ARK.

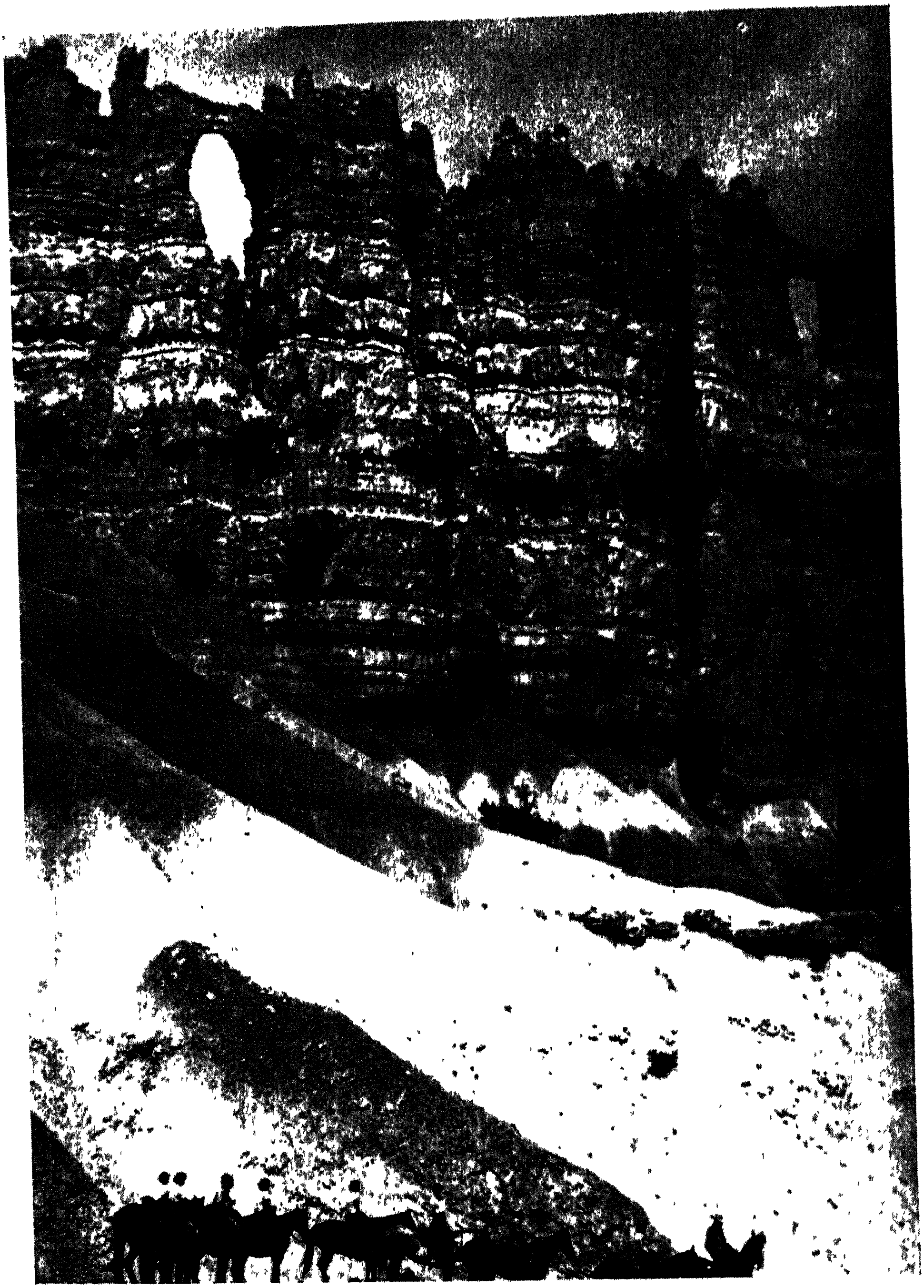
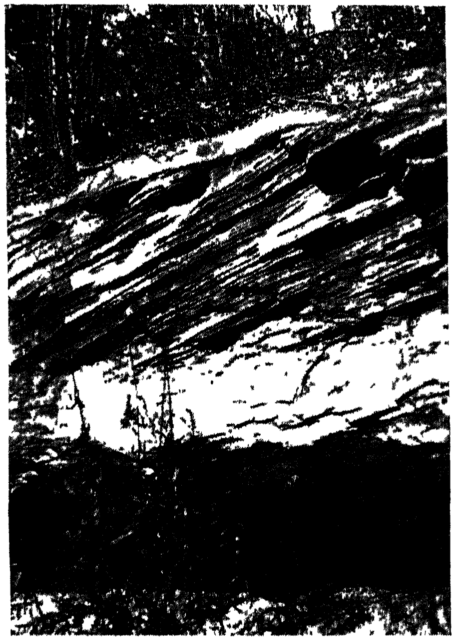


Photo courtesy Chicago & Northwestern Ry.

BEDROCK WEATHERING

RAIN AND WIND COMBINE THEIR FORCES TO BREAK DOWN MASSIVE ROCK IN BRYCE CANYON NATIONAL PARK, RESULTING IN ENORMOUS HEAPS OF TALUS, OR SLIDE-ROCK, AT THE BASE.

Photos by author

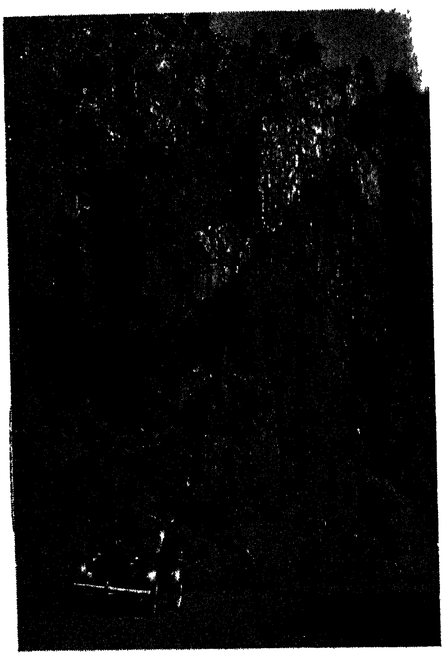
CHEMICAL WEATHERING OF SANDSTONE

Left, SOLUTION HOLES ALONG BEDDING PLANE OF OVERTURNED SANDSTONE AT CASCADE CAVERNS, KY. *Right*, THINLY BEDDED STRATA OF UNEQUAL RESISTANCE PRODUCE ALTERNATING RIDGES AND DEPRESSIONS ON WEATHERED SURFACE NEAR ASHLAND, KY. NOTE SCALING-OFF OF MASSIVE LAYER NEAR BASE.

ward through the interspaces of the soil, slowly weather the bedrock beneath, breaking it into smaller particles, even though the rock is blanketed by many feet of mantle. If the topsoil is not carried away too fast, this slow weathering of the rock beneath continues in pace with the normal erosion of the soil above. Thus, under normal conditions in most areas of the world, the soil mantle, as a unit, would remain essentially static were it not for improper agricultural practices that permit erosion to operate faster than new soil can be formed by weathering. If researchers in rock-weathering could discover practical means whereby natural weathering could be greatly speeded, some of our serious erosion problems might be solved.

Theoretically, rock-weathering is considered by geologists as being merely the process whereby massive rock is disintegrated or decomposed into smaller and finer particles, regardless of the manner in which it is accomplished. Erosion, on the other hand, involves the removal of these particles from their original sites to any other location, their ultimate destination usually being the sea. From a practical standpoint, however, it is not always possible to differentiate clearly between weathering and erosion, since the two are so interrelated that they usually aid and abet each other. This is particularly true where so-called mechanical weathering appears to be the dominant factor. Because rock is a relatively poor conductor of heat, the sun's rays cause exposed surfaces to become heated and expanded more than the interior, resulting in strains that weaken the rock. At night there may be a reversal of this condition, the rock surfaces

losing their heat and becoming colder than the inside. Such expansions are characteristic of desert and semiarid regions where temperatures may be quite high in daytime and correspondingly low at night. As a result of these expansions and contractions over long periods, the rock finally yields by shelling off its outer layer. As fresh surfaces are exposed, the process is repeated. Although such action may be primarily mechanical, it is aided by chemical reactions when small amounts of moisture enter the cracks developed in this way and further the decomposition of the mineral matter comprising the rock. The loose shells of rock which thus fall away from the parent mass are not completely weathered, however, and may lie for many years on the ground before they are finally broken into particles small enough to be picked up by erosion agents and carried away. The great structure known as Half Dome, in Yosemite National Park, exhibits this form of weathering in enormous degree.



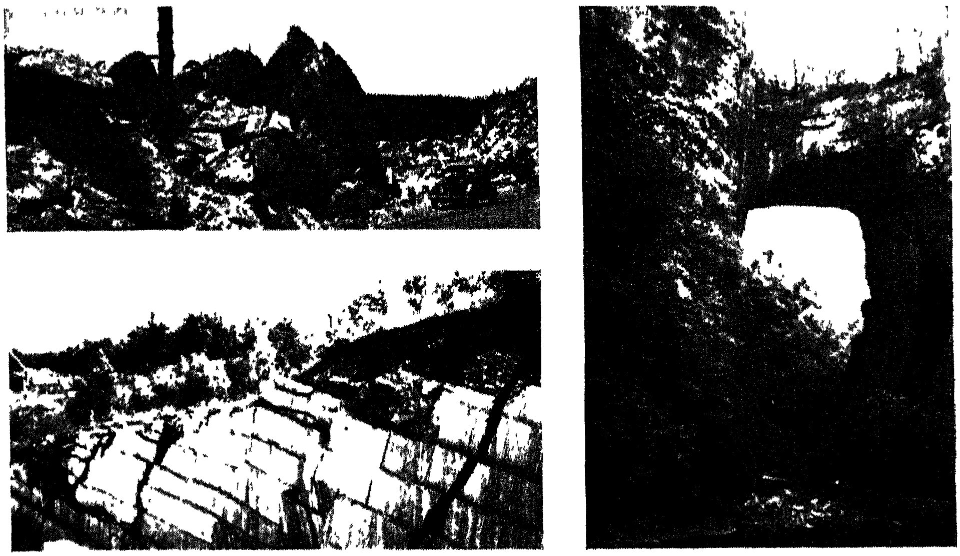
Photos by author

CHEMICAL WEATHERING OF GRANITE

Above, LARGE BOULDERS HAVE BEEN SMOOTHED BY RAIN-WASH ON A HILLTOP NEAR PIKE'S PEAK, COLO. *Below,* WEATHERING CONTROLLED BY JOINT CRACKS IN MASSIVE GRANITE OF BIG THOMPSON CANYON, COLO

CLOSELY related to the foregoing process is that wherein water enters the crevices and pores of rocks and becomes frozen when the temperature drops. The expansion of the ice may exert sufficient pressure to pry the rocks apart, and, with alternate periods of thawing and freezing, great chunks of rock may be loosened and fall away from the main rock mass. In the same way, the roots of trees penetrating down into small rock fissures may exert sufficient force while growing to lift and pry away large slabs of rock. In addition, the mere difference in physical characteristics of alternating layers of rock may contribute to their disruption. Common examples of this may be seen wherever there are overhanging cliffs. Here soft, or more easily weathered, strata of rocks are topped by more resistant layers. The former, in weathering, are cut back under the overlying layers, eventually contributing to the downfall of the harder layers.

Theoretically, mechanical weathering can be distinguished from chemical weathering. The former is simply the breakdown of the parent rock mass into smaller pieces of vary-



Photos by author

CHEMICAL WEATHERING OF LIMESTONE

Upper left, WEATHERING OF TUFA ROCKS ON SURFACE OF GROUND BY ATMOSPHERIC AGENTS IN YELLOWSTONE NATIONAL PARK. *Lower left*, SUBSURFACE WEATHERING ALONG CRACKS IN MASSIVE LIMESTONE, AS EXPOSED IN A QUARRY NEAR ST. GENEVIEVE, MO. *Right*, GREAT NATURAL BRIDGE OF VIRGINIA, DEVELOPED BY SOLUTION UNDERGROUND, PRODUCING A CAVERNOUS TUNNEL, THE ROOF OF WHICH SUBSEQUENTLY COLLAPSED EXCEPT FOR THE SPAN WHICH CONSTITUTES THE BRIDGE.

ing size and shape, enabling them to be moved by gravity or by eroding agents. Chemical weathering, however, involves an actual chemical change in the composition of the minerals comprising the rocks. Air and water, particularly if combined with carbonic acid from decaying vegetation, are powerful decomposers of rock materials; hence these agents literally tend to eat away the rock minerals. If any part of the mineral constituents of a rock mass is thus decayed away, the remaining structure may become so porous and weakened as to be much more easily attacked by mechanical processes. Only under very limited conditions are rocks completely weathered solely by one or the other means. Usually both forces operate together. It can be readily understood that when rocks are disintegrated by mechanical means, the smaller fragments expose a greater total surface area to the attack of chemical agents, permitting the latter to perform their work more effectively. And this, in turn, may quicken further mechanical breakdown. Some types of rocks and minerals, such as limestone, marble, salt, and gypsum, are quite susceptible to chemical attack; whereas others, such as shale, quartzite, and many volcanic rocks, are not and are therefore broken down principally by mechanical means.

Having been weathered, all rock particles are subject to transport, technically called erosion, whereby they are removed to other locations and ultimately to the sea. Depending upon the region, the erosion agents are wind, ice, or water. Operating most effectively in arid regions, the wind picks up the smaller weathered particles, such as dust and fine sand grains, often carrying them great distances before dropping them again. During the exceptionally dry periods of 1934–36, enormous dust storms, originating in the Great Plains of the United States,

Photos by author

WIND ABRASION OF SANDSTONE

Above, FAMOUS BALANCED ROCK AND MUSHROOM ROCK, IN GARDEN OF THE GODS, COLO., OWE THEIR SHAPES TO THE ABRASIVE POWER OF THE WIND, WHICH HAS BEEN GREATEST NEAR THEIR BASES. *Lower left*, SPIRES DEVELOPED IN UPENDED STRATA IN THE GARDEN OF THE GODS ARE THE RESULT OF COMBINED MOISTURE AND WIND ACTION *Lower right*, CAVES DEVELOPED BY SIMILAR AGENTS IN HORIZONTAL BEDS NEAR WALSENBURG, COLO.

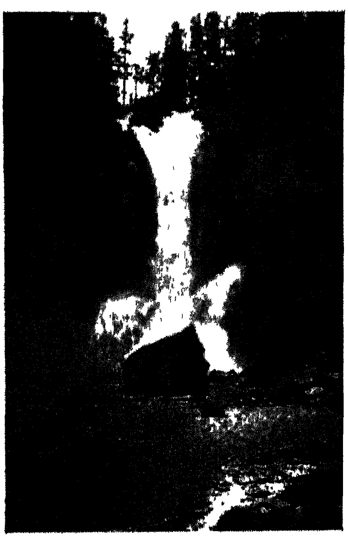
swept eastward across the continent. At Chicago, Detroit, and farther east, these storms were of such intensity as to black out the sun at midday. In some instances, the storms raced onward over the Atlantic, and sailors on ships at sea actually swept the dust of our Western prairies from their decks.

The wind, as an erosion agent, may also do much weathering. The loose sand grains, as they are blown along, may be hurled against projecting masses of rock with such force as to abrade, or wear away, their surfaces by a natural sandblast. Since the wind usually cannot lift sand grains very high from the ground, most of the sandblasting

action occurs within a few feet of the ground. This results in undercutting of the rocks to produce many curious rock formations, such as "toadstool rocks," balanced rocks, and oval caves in cliffsides. Oftentimes telephone poles and fence posts are cut off near the ground line by such sandblasting.

Running water, because of its almost universal distribution, is generally conceded to be the most important erosive agent. Most readily understood of all geologic processes is the part that surface streams play in land erosion by carrying away in suspension most of the weathered products of their drainage areas. In order to study the transporting power of streams, gauging stations are maintained near the mouths of many large rivers. In this way it has been determined that the Mississippi River normally carries more than a million tons of sediment daily to the Gulf of Mexico. Less well known, however, is the fact that these suspended particles of sediment may themselves act as further agents of weathering, as do the wind-carried particles. While being swirled along in the streams, the grains strike against the sides and the bedrock of the stream channels, grinding off additional particles of rock. It is also recognized that streams may transport stones that are too large and heavy for them to carry by suspension. They do this simply by rolling or buffeting them along their beds. Because of their greater gradients, tiny mountain streams may do this even more effectively than large, sluggish rivers. Frequently such stones roll into irregular depressions of the stream bed. If they are too heavy to roll out of the depression again, they may be swirled around and around in it, resulting in the grinding out of deep hollows, termed potholes. A long series of these may be spaced so close together as to coalesce, or cut into one another, eventually lowering the stream bed.

Any stream, whether it be on the surface or underground, and depending upon the kind of rock over or through which it is flowing, may also dissolve the rock. This is most pronounced where subsurface streams flow through crevices in limestone or other solu-



Photos by author

STREAM ABRASION

Left, A LARGE BOULDER, RECENTLY BROKEN FROM THE STRATA AT A WATERFALL IN GLACIER NATIONAL PARK, HAS NOT YET BEEN REDUCED BY ABRASION. *Right* BOULDERS IN ANOTHER STREAM HAVE BEEN GREATLY ABRADED AND ROUNDED BY IMPINGEMENT OF STREAM-BORNE PARTICLES AGAINST THEM.

ble types of rocks. This is, of course, a chemical action wherein the rock is weathered and carried away immediately in solution. All our large and beautiful caverns, such as Carlsbad, Mammoth, and Luray, were hollowed out by extended enlargement of cracks in the limestone by this dissolving power of running water.

Even nonflowing waters, such as the sea itself, are powerful weathering and eroding agents along the shores where they come into direct contact with the land. Rocky sea cliffs are battered to pieces by the onslaught of the waves. This is accomplished largely by the air that occupies the crevices in the rocks becoming compressed when the waves slap against it. The compressed air then tends to spread the rocks apart, eventually weakening them to the crumbling point. The broken rocks fall to the beach, where the waves pound them into fragments small enough to be carried out to sea by the undertow and alongshore currents.

In some respects, ice may be the most powerful eroding agent of all, particularly in regions where it occurs as enormous glaciers. Because of its rigidity, ice offers greater resistance than does either water or wind; therefore, when glacial ice moves over rock surfaces it may actually gouge out rocks that neither wind nor water could easily reach. The rock fragments thus gouged out may then become frozen in the bottom of the glacier and abrade the surfaces over which they move. In this way the glacier acts like a gigantic piece of sandpaper, grinding down the lands over which it passes. Also, in contrast to flowing water, which receives its momentum from gravity, glaciers may actually move uphill, wearing off the tops of hills and mountains as they ride up and over them. The method of uphill movement of ice may be visualized by likening a glacier to a string of railroad cars that are being pushed upgrade by a locomotive. The glacial ice accumulates from compacted snow that has fallen in the region of greatest precipitation. After a sufficient thickness of ice has thus been mounded up (usually several hundred to a thousand feet or more), it begins to move under its own weight, continuing to move thereafter as long as snow continues to be added at the accumulation point. The pressure thus created may cause the extremities of the glacier to move uphill if any elevations stand in its path. Thus the forward end of a glacier may act like a gigantic plow as it is shoved along.

Valley glaciers, those long, narrow rivers of ice that characteristically move down the sides of high mountains, are enormous carriers of rock debris. As they slowly wind their way down through the valleys, the flowing ice tends to conform to the valley shapes, but because the ice is nevertheless rigid, it cuts away at the sides and bottoms of the valleys, ever widening and deepening them by abrasion against the rock. As the valleys are cut wider and deeper, the upper parts of the valley walls may be left so poorly supported that slides and avalanches catapult down upon the glaciers from overhead. This material, often consisting of rocks and boulders of immense size, then rides along on top of the glaciers as though on great sleds. In this way rocks larger than houses can be carried along by the moving ice, a feat impossible for wind or water to accomplish.

Since, by definition, rock-weathering is the process of disintegrating or decomposing the rock into smaller pieces, and erosion is that of carrying these particles away, it should follow that the two processes are distinct in themselves. Yet, when one observes these activities taking place, it is virtually impossible to draw sharp lines between them. At what point do wind, water, and ice cease to break rock and, thereafter, merely transport it? The two processes may actually work simultaneously, and further

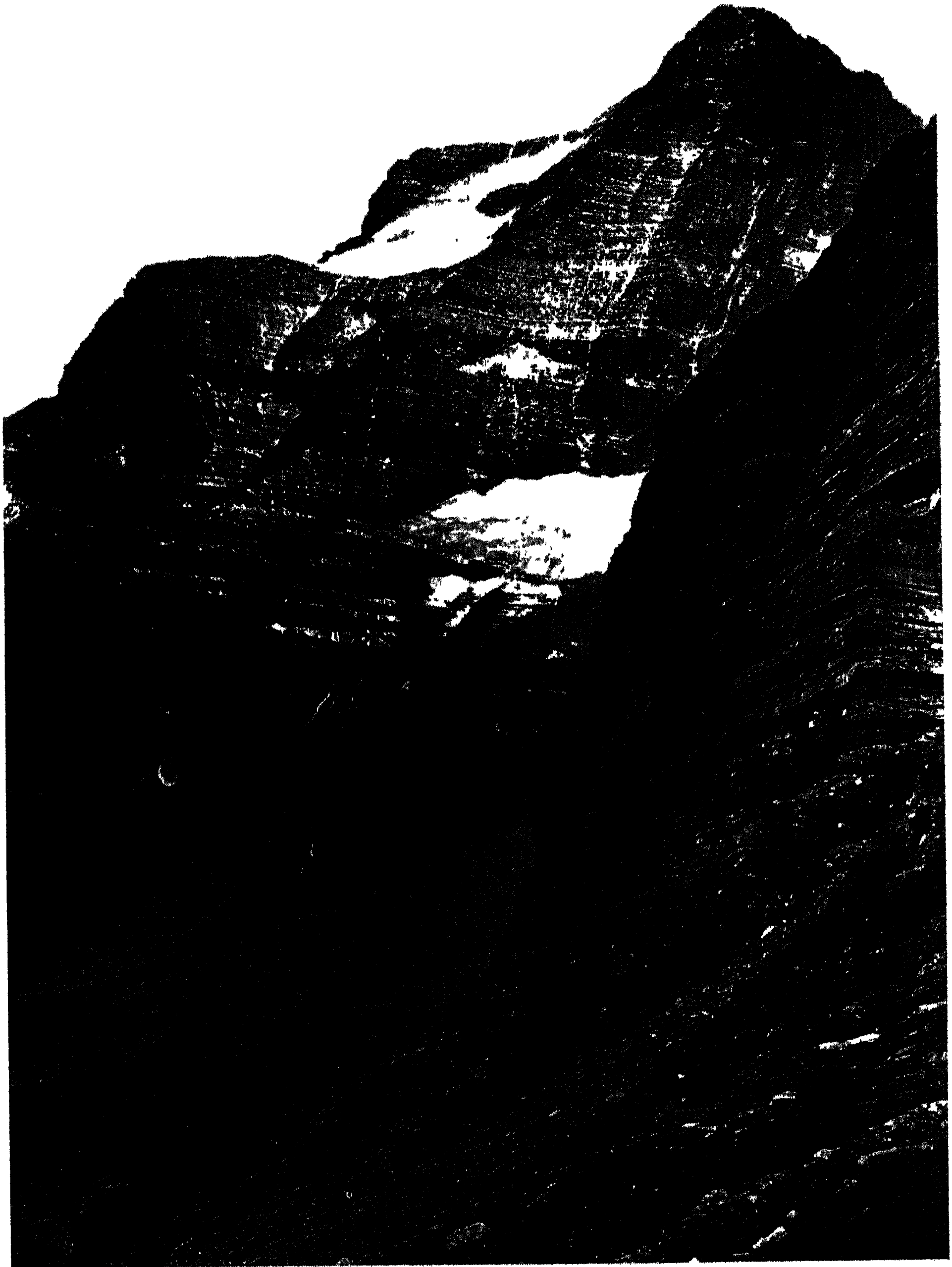


Photo courtesy National Park Service

ROCK PILED ON ROCK

THE DESTRUCTION OF MOUNTAINS IS WELL ILLUSTRATED BY GOING-TO-THE-SUN MOUNTAIN, IN GLACIER NATIONAL PARK, WHERE COUNTLESS ROCK LAYERS, HERE EMPHASIZED BY THE SNOW, ARE BEING SLOWLY WEATHERED AWAY AND CARRIED TOWARD THE SEA FOR ACCUMULATION OF STRATA OF A FUTURE AGE.

weathering may continue while the fragments are being transported. Only in the case of chemical weathering, wherein the rock material is completely dissolved and combined with the moving water, does weathering cease before final deposition in the sea. It is also true that neither weathering nor erosion could long continue without the other. Without weathering there would be no rock particles to be transported; and without erosion the weathered fragments would accumulate to such depths that the agents of weathering could not penetrate beneath the debris, and further weathering would cease. We have only to study the surface of our moon in order to visualize a condition wherein weathering and erosion do not occur. Because there is no atmosphere and no water on the moon, its surface remains unchanged except for the impact of falling meteors.

The profound effects resulting from the combined action of weathering and erosion account for nearly all the geologic changes that occur on the surface of the earth. The only exceptions are the processes of volcanism, faulting, and regional uplift, wherein new lands may be built and old ones shifted in position. But even these may be, in part at least, an indirect result of weathering and erosion. It is evident that, after vast lands and mountains have been eroded and the materials that comprised them have been deposited in the sea, a redistribution of weight has occurred. The lands have become lighter from the loss of material, and parts of the sea bottom have become heavier by the addition of these sediments. The added weight on the sea floor appears to cause it to sink, yet sinking toward the center of the earth cannot continue indefinitely because of its already greater density. The pressure, therefore, may be distributed laterally to the adjacent lands, apparently causing re-elevations. In this way, new mountains may be born or old ones uplifted. Then the cycle begins anew, for the recently elevated lands are at once attacked by weathering and erosion agents. Such cycles are the basis of subdividing geologic time, each major uplift marking the end of one period, or era, and the beginning of a new one. It can also be seen that the same grains of sand and silt may be used over and over again during successive periods of the earth's history. The grains of sand carried down from the heights of the present Rockies by the mighty Colorado River are used en route for the cutting of the Grand Canyon, finally being deposited in the Gulf of California. Here they will be consolidated into rock layers that in some future age will be uplifted to make new lands, whereupon they will once again be subjected to weathering and erosion and be carried downward to another sea. Although millions of years may have elapsed, the individual sand grains may even retain their identity in form and substance. Thus it is paradoxically true, perhaps, that the rocks are both ephemeral and everlasting!

To weathering and erosion, then, may be attributed nearly all those natural features of the earth considered beautiful in the eyes of man: the towering mountains, peaceful valleys, sweeping hills, broad plains, and dashing waterfalls. There are few individuals who can look upon beautiful scenery without experiencing some inward feeling of emotion at the wonders displayed before them. Such vistas may at first appear mysterious and meaningless but, upon study and contemplation, may be read like the pages of a book. It is the mighty history of an ever-changing earth wherein rock piled on rock is slowly crumbled away, only to be rebuilt from the products of its own destruction into new rocks of some succeeding age. The words of the prophet, written several millennia ago, still ring with truth:

> The everlasting mountains were scattered: the perpetual hills did bow: his ways are everlasting.—Hab. 3:6.

THE IONOSPHERE*

By J. H. Dellinger

Dr. Dellinger (Ph D., Princeton, 1913) has been a physicist at the National Bureau of Standards since 1907. He is now chief of their Division XIV, Central Radio Propagation Laboratory. He has had a distinguished career in radio, having represented the United States at many international radio conferences. He is Vice-president of the International Scientific Radio Union and Chairman of the Radio Technical Commission for Aeronautics

THE ionosphere is the frontier between geophysics and astronomy. Its exploration is providing evidence and elucidation of the control of geophysical phenomena by the sun. It is mainly by observations of radio propagation that the evidence and elucidation are secured. Geomagnetism, aurora, and related fields, such as earth currents, also contribute. By means of the correlations with solar phenomena established by observations in these geophysical fields, the fields themselves are in turn greatly benefited, even to the point that observations of solar events permit predictions of geophysical events. In the case of radio propagation the practical benefits are so great that a world-wide observing program has been established during the past five years and is being further developed.

The ultraviolet radiation and electric particles from the sun and its corona that reach the earth's atmosphere produce ionization which varies in time and is different in different strata, depending upon chemical composition, state of dissociation, density, and temperature. This ionization and its stratification and variations are the major characteristic properties of the gaseous envelope of the earth at altitudes greater than about 40 km. above the earth's surface. A rough sketch of the atmospheric structure is shown in Figure 1. There are a number (commonly three: E, F_1, F_2) of ionized layers that reflect radio waves, and a lower layer or region (D) whose outstanding role is to absorb radio wave energy.

The ionization density and heights of these layers change with time of day, from day to day, with season, and from year to year. They are also very different at different geographical locations. The first great controlling cause of the ionosphere variations is the sun's ultraviolet light. Varying amounts of such light at different frequencies pour forth from the sun, increasing and decreasing with solar activity (roughly indicated by the sunspot number). The ionization of the several layers of the ionosphere, in consequence, varies with the sunspot number. From the ionizations and heights of the layers and from energy-absorption data are calculated the distance ranges of radio sky-wave transmission, and the upper and lower limits of frequency in which radio sky-wave transmission is possible.

Besides the ultraviolet light, the sun emits electric particles in an amount that is much less regular and more sporadic. These particles introduce variations and irregularities in the ionosphere's characteristics and in radio propagation which interfere with the more predictable trends occasioned by the general ultraviolet-light radiation. At times great outbursts of these particles produce extensive effects which, taken together, are described as an ionosphere storm. The recognition of the effects produced by an ionosphere storm upon radio propagation and the forecasting of the times of such occurrences are very important.

* Presented at the Harvard Centennial Symposium, December 30, 1946, Cambridge, Mass. This paper will be included in the Observatory Centennial Volume

I SHALL here discuss primarily what is done to determine the characteristics of the ionosphere and something of their significance. The determination of ionosphere characteristics is essentially a radio observing program. From certain types of radio observations we obtain the characteristics of the ionosphere and their effects upon radio propagation. As these effects are in constant change, the observing program and the predictions based upon it become a great undertaking analogous to the weather observation and forecasting program. It has to be world-wide because the ionosphere characteristics vary with latitude and longitude and with geomagnetic latitude.

The nature and technique of the measurement of ionosphere characteristics by radio means have been amply described in numerous publications. They include chiefly determination of: layer height, by oscillographic measurement of time of travel of radio pulses reflected by the layer; ionization density, by observation of the upper limit of radio frequency that can be reflected; energy absorption, by recording of intensity of received radio waves. These measurements are made upon both vertically and obliquely reflected waves. Associated with these determinations, and necessary for radio propagation predictions, are measurements of radio noise, both the geophysical type, caused principally by thunderstorms, and the extraterrestrial types, stellar and solar.

We are now in the fortunate position of

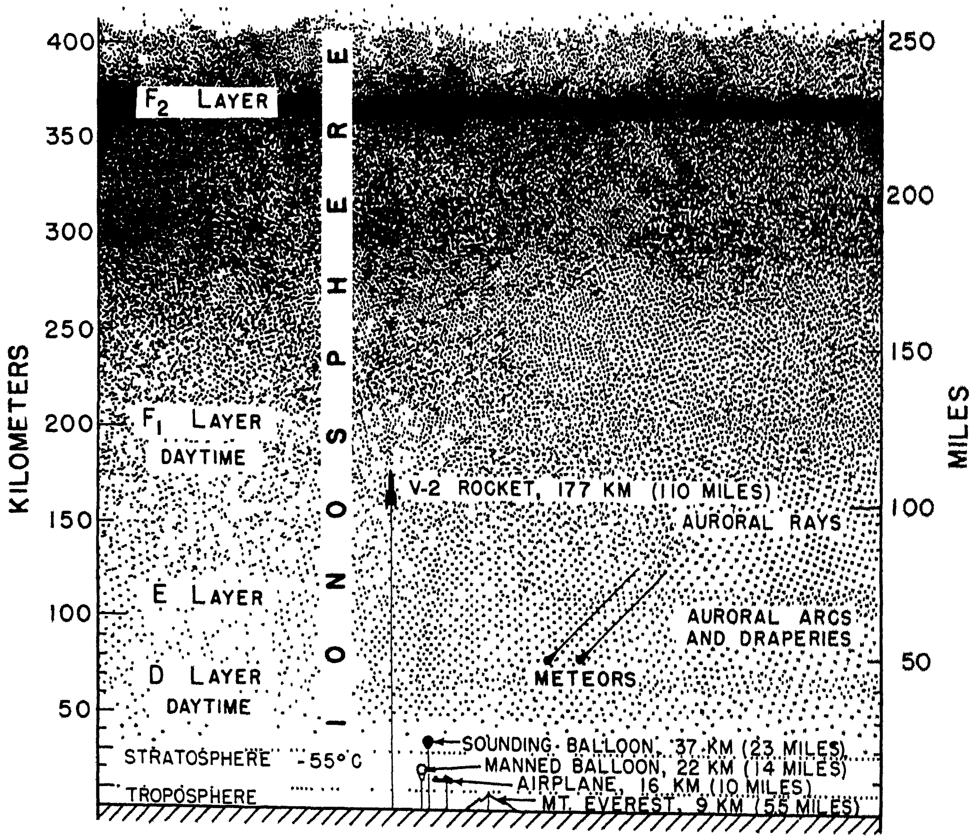


FIG. 1. STRUCTURE OF THE ATMOSPHERE

IONOSPHERE LAYER HEIGHTS AND IONIZATION ARE MERELY A SAMPLE. THEY VARY FROM HOUR TO HOUR.

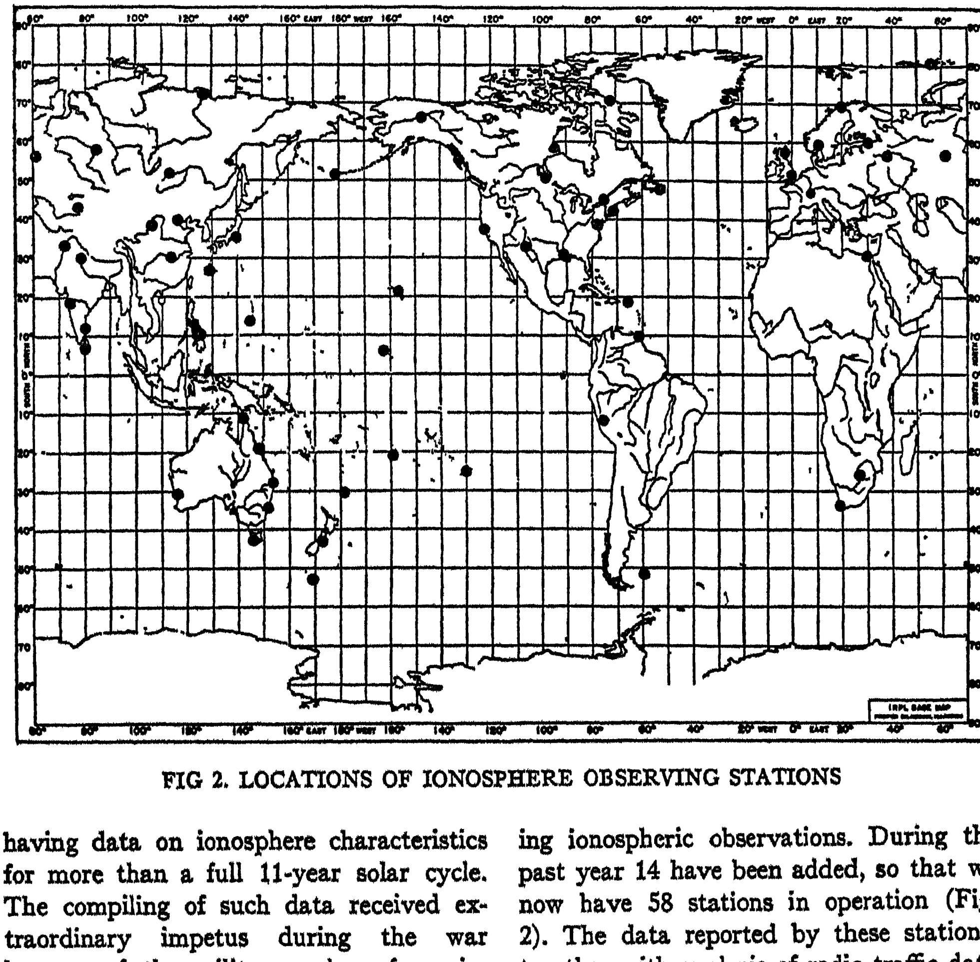


FIG 2. LOCATIONS OF IONOSPHERE OBSERVING STATIONS

having data on ionosphere characteristics for more than a full 11-year solar cycle. The compiling of such data received extraordinary impetus during the war because of the military value of precise knowledge of the usability of the various radio frequencies at specific times over specific transmission paths. Peacetime has continued and even intensified the recognition of the need for such data because of their added importance for commercial radio applications and their value in solar and geophysical sciences.

During the war laboratories were established to centralize ionospheric data for the military services, in England, the United States, Australia, the U. S. S. R., Canada, and in the enemy countries as well. The Allies cooperated in maintaining world-wide observations. By the end of the war no less than 44 stations were regularly reporting ionospheric observations. During the past year 14 have been added, so that we now have 58 stations in operation (Fig. 2). The data reported by these stations, together with analysis of radio traffic data from a number of communication networks, have permitted the continual improvement of world charts of predicted ionosphere characteristics, from the beginning in 1941, based on only three stations, to the comprehensive charts now published monthly by the Central Radio Propagation Laboratory (CRPL), National Bureau of Standards. The knowledge gained from the greatly expanded world-wide ionospheric coverage has permitted a much improved delineation of the regular variations of the ionosphere with latitude and local time.

One consequence of the improved world-wide coverage was the discovery of the longitude effect in 1943. This was the

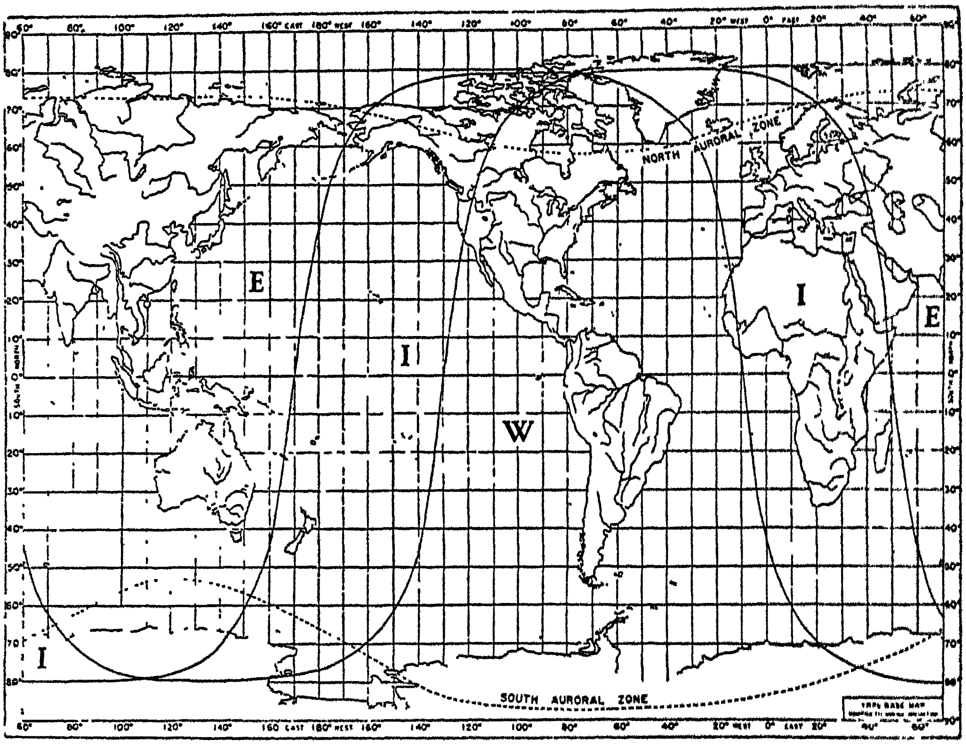


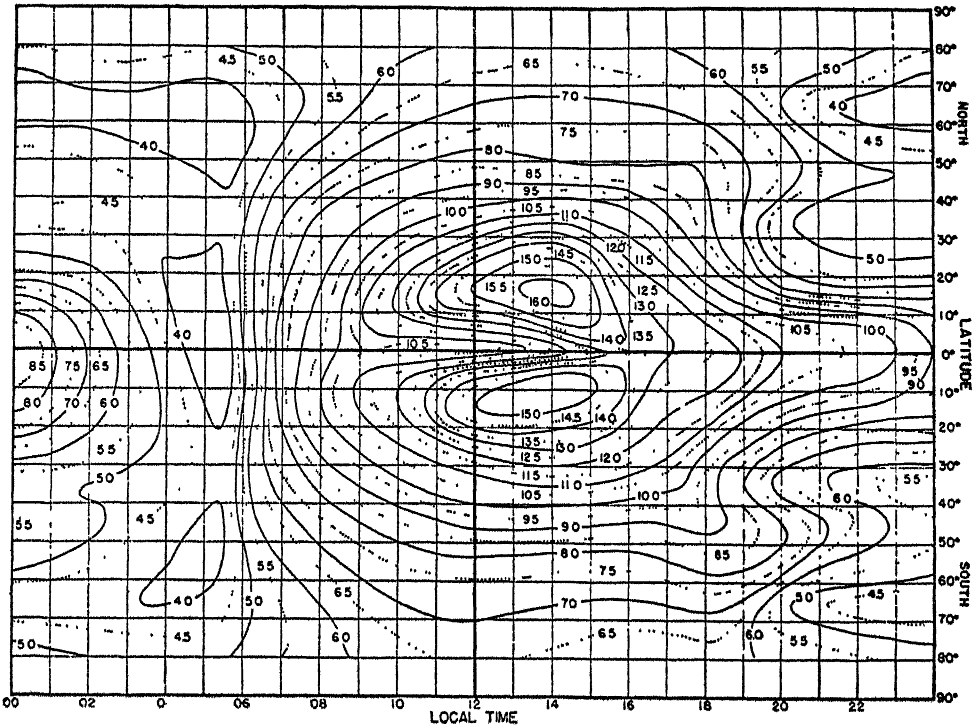
FIG 3. WORLD ZONES FOR PREDICTIONS OF RADIO PROPAGATION

THE WORLD IS ZONED BECAUSE OF LARGE VARIATIONS OF IONOSPHERE CHARACTERISTICS WITH LONGITUDE.

discovery that ionosphere characteristics are not the same, at the same local time, for stations at the same latitude but different longitudes. Instead, they depend to a great extent on the geomagnetic latitudes of the station. Thus the station at Delhi, India, shows quite different characteristics from those observed at Baton Rouge, La., at about the same geographic latitude. Following this discovery, the world was divided, for practical prediction purposes, into the three zones shown in the map (Fig. 3). In each zone the characteristics are roughly independent of longitude, to a good enough practical approximation for radio propagation predictions.

From vertical-incidence data reported from the observing stations all over the world, the CRPL prepares charts for calculation of the maximum usable frequency (muf) on any transmission path. Three sets of predicted F_2-layer ionosphere charts are prepared for each month, giving, for the three zones, the zero-distance muf and the 4,000-km. muf (see Figure 4). An E-layer and a sporadic-E muf chart are prepared, also for each month (Figure 5). From these the muf can be calculated for any transmission path anywhere in the world. The charts are published three months in advance of the month for which the predictions are made. They are in the monthly CRPL publication *Basic Radio Propagation Predictions*, obtainable from the Superintendent of Documents, Government Printing Office.

Data on ionospheric absorption, of use in calculating radio distance ranges and lowest useful high frequencies, are obtained by observation of the intensities of received radio waves. Continuous records of received intensities are made at many of the



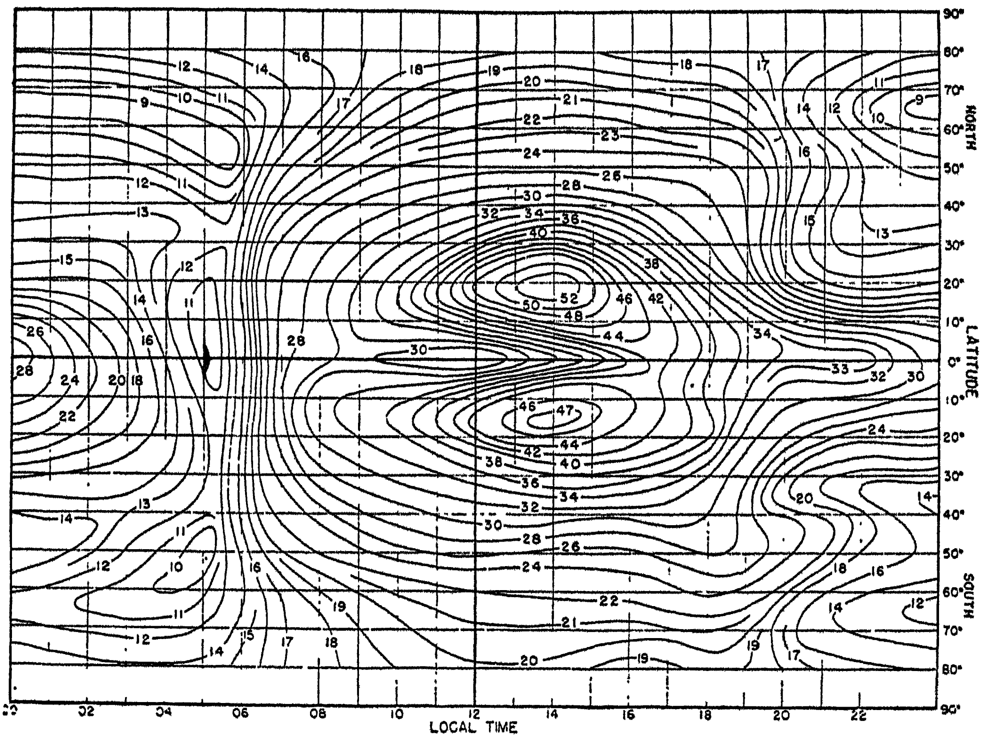


FIG. 4. F_2-LAYER MAXIMUM USABLE FREQUENCY IN MEGACYCLES
Above, VERTICAL INCIDENCE. *Below*, FOR 4,000 KM. BOTH I ZONE PREDICTIONS FOR MARCH 1946.

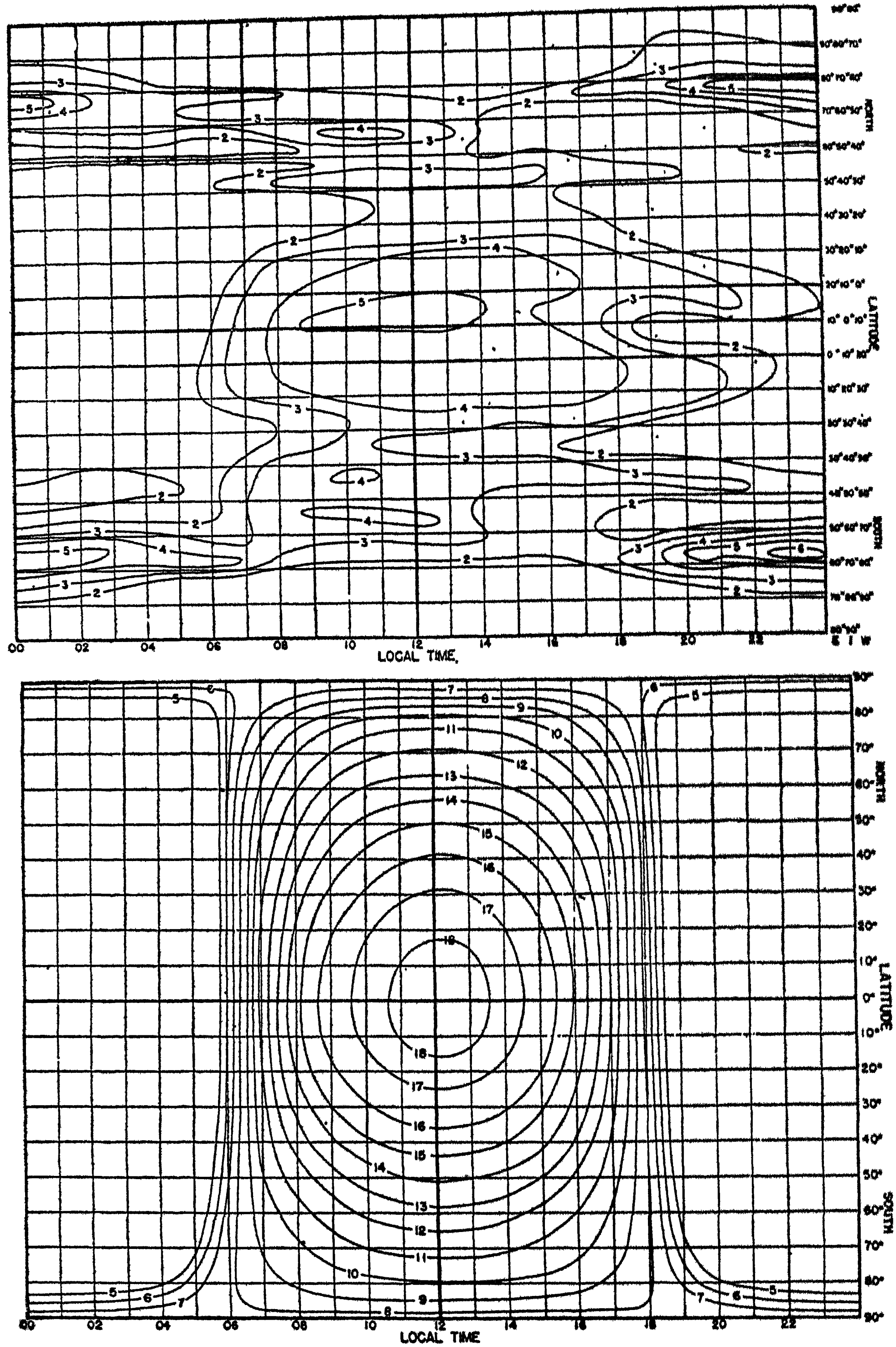


FIG. 5. MAXIMUM USABLE FREQUENCY IN MEGACYCLES

Above, SPORADIC E, VERTICAL INCIDENCE. *Below.* E-LAYER, FOR 2,000 KM. PREDICTIONS FOR MARCH 1946.

ionosphere observing stations. Figure 6 shows a sample automatic field-intensity record. Studies of oblique- and vertical-incidence ionospheric absorption based on such data have been made and continue. An equivalence theorem, similar to that used in calculating maximum usable frequencies, is used, employing the observed field-intensity data to supply numerical values to the many uncertain factors in the equation for absorption. It is found that the diurnal variation of ionospheric absorption varies, on the average, linearly with the cosine of the zenith angle of the sun, a fact that simplifies greatly the integration of ionospheric absorption over a given transmission path: the absorption can then be determined as a function of frequency, distance, and average solar zenith angle over the paths. For rapid calculation, charts of absorption index (Fig. 7) are drawn, K being defined as unity at the subsolar point and zero at night. Based on such a chart, calculations for actual received radio intensities for particular transmission paths are made with the aid of nomograms.

The body of absorption data, accumulated for practical use in radio operations, is being analyzed in the light of physical principles and is expected to yield important knowledge of ion collisional frequencies, mean free paths, and atmospheric temperatures and densities.

Study of absorption of radio waves propagated through the absorbing layer, which exists in daytime below the E-layer, shows close correlation with solar activity as measured by sunspot numbers. Analysis of the vertical-incidence absorption measurements by CRPL from 1944 to 1946 indicates the trend of this absorption. Preliminary estimates indicate that the coefficient of absorption increases by about 60 or 70 percent for an increase in annual average sunspot numbers from 0 to 100. It is interesting to note that this is roughly equal to the increase in amplitude of the quiet-day variations in terrestrial magnetism for corresponding increases in sunspots. This long-time trend has been recognized for some time. More recently it has been discovered that even the short-time changes in sunspot numbers affect absorption so that the sun's rotation period is reflected in the day-to-day variations in absorption. The magnitude of these short-time changes in absorption appears to be slightly less than the long-time changes,

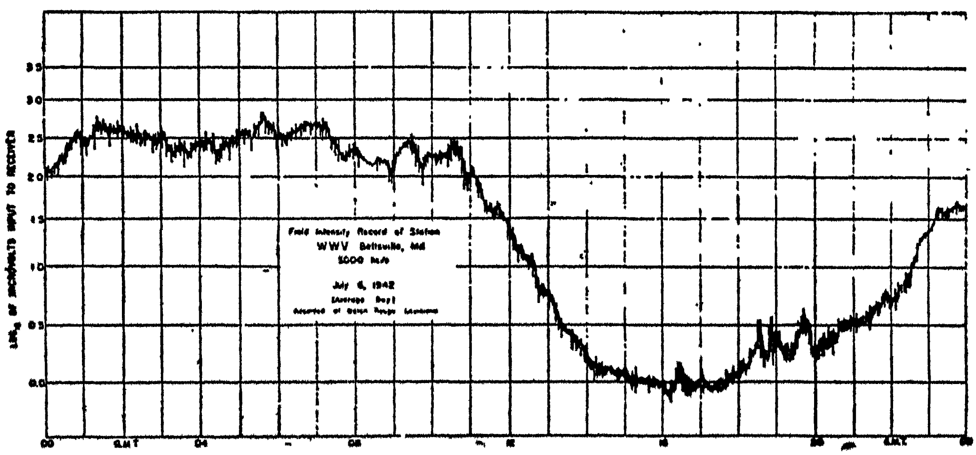


FIG. 6. SAMPLE AUTOMATIC RECORD OF FIELD INTENSITY FOR NORMAL DAY

but they are sufficiently large to have importance in communication problems. These effects are illustrated in Figure 8 by the superposed epoch method, where sunspot sequences for 13 intervals of 54 days were selected and superposed with sunspot maxima centered in the interval; absorption figures for the same 13 epochs were also superposed in an identical manner. Roughly the same characteristics appear in the absorption and in the sunspot numbers.

THE less predictable characteristics of the ionosphere, such as the stormy periods that ensue when great showers of electric particles arrive from the sun, are no less important than the more or less regular and predictable phenomena discussed in the foregoing. During periods of ionosphere storms the ionosphere is turbulent, the ionization density of the upper layers is diminished, layer heights increase, and radio communication is difficult.

There are times, too, when quantities of ultraviolet radiation vastly in excess of normal are emitted by the sun and destroy high-frequency radio transmission completely. These occurrences are great explosions on the sun and often include visible radiation so that the solar eruption can be actually seen simultaneously with the radio fade-out. The effect begins very suddenly and lasts from a few minutes to a few hours. Its consequences exist in the ionosphere throughout the earth's hemisphere illuminated by the sun. The sudden destruction of radio reception is illustrated in Figure 9; received intensity became zero simultaneously throughout the daylight half of the earth, as shown by the field intensity records; a simultaneous kink may be

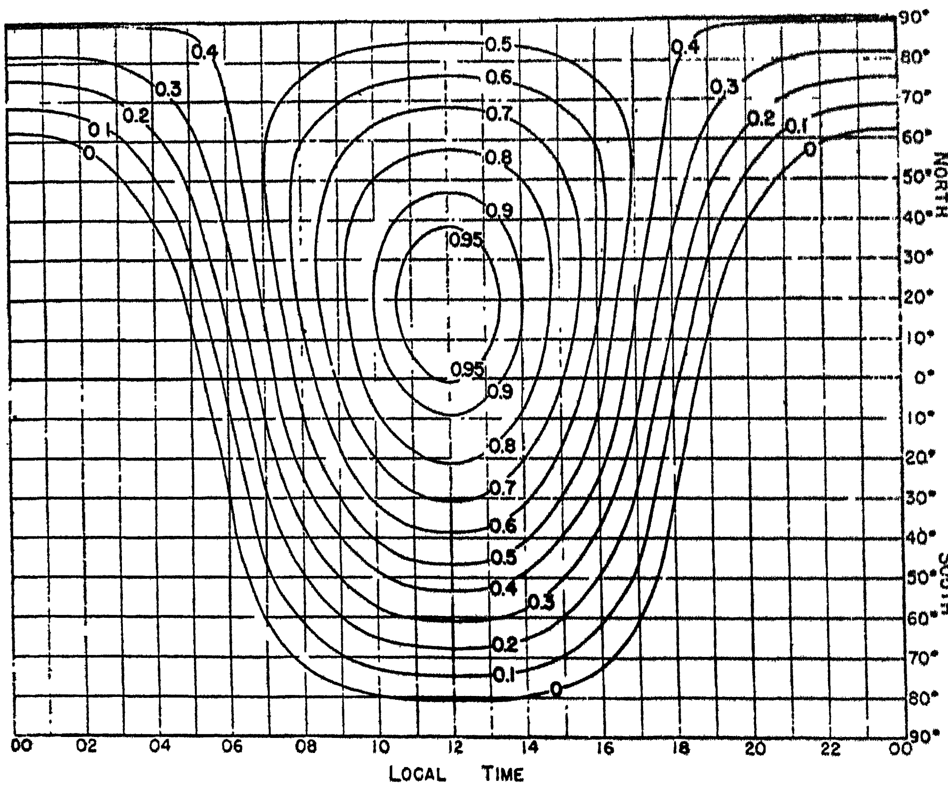


FIG 7. ABSORPTION INDEX K FOR MONTH OF MAY

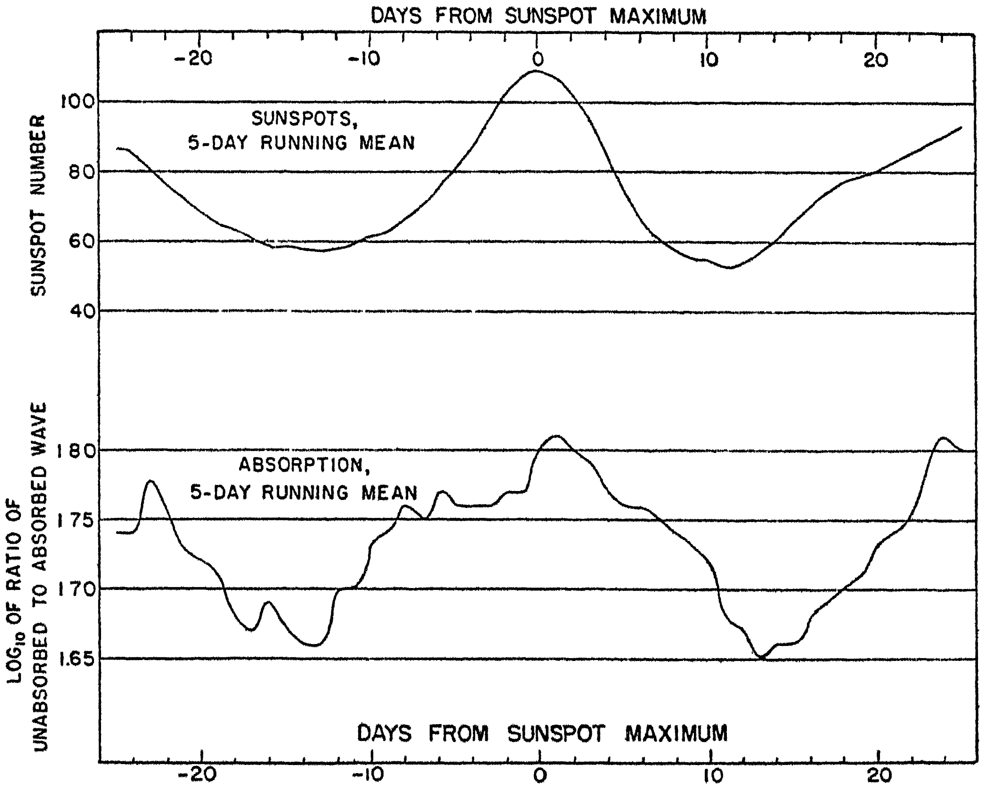


FIG 8. SUNSPOT NUMBER AND RADIO ABSORPTION

COMPARISON OF SHORT-TIME VARIATIONS (VERTICAL INCIDENCE, 2,061 KC.), 1945–46.

seen in the magnetograph records shown.

The effects of ionosphere irregularities upon radio systems of navigation are particularly serious; e.g., varying layer heights change the time of arrival of radio pulses and thus give false indications in the Loran and similar systems. Ionosphere turbulence and spotty ionization produce rapid changes in the polarization and direction of arrival of radio waves at a receiver. These effects and transmission over multiple paths produce serious errors in radio direction finders.

Ionosphere storms are so detrimental to the various radio services that the forecasting of their times of occurrence is important. The scheduling of major broadcasts is an example of the need of such forecasts. Another is long-distance flying, which depends heavily upon radio messages giving weather information, etc., and upon radio systems of navigation. Ionosphere storm effects are at a maximum in the auroral zone, and thus the very extensive radio communication and navigation across the North Atlantic are vitally affected. Here, solar observations come to the direct aid of the student of the ionosphere. A weekly forecast is issued by the Central Radio Propagation Laboratory, based in large part upon coronagraphic and other solar observations reported daily by four solar observatories, namely, McMath-Hulbert (Colorado), Harvard, Mt. Wilson, and the Naval Observatory. In these forecasts use is also made of geomagnetic and radio observations. The forecast gives a prediction of future periods in which disturb-

ances are most probable and also gives a rough estimate of the quality of radio reception, on a numerical scale, in several zones (Fig. 10). The greatest disturbance is in Zone A and the least in Zone C. The boundaries of the zones shown are coincident with geomagnetic latitude lines.

This weekly forecasting service is supplemented by a warning of radio disturbance, caused by ionosphere irregularities, a few hours to a day in advance. This is based largely upon observations of radio direction-finder bearings over the North Atlantic path. The warning service is broadcast from the National Bureau of Standards radio station WWV twice each hour (at 20 and 50 minutes past the hour).

There is another agent besides the sun that plays a part in ionizing the ionosphere, namely, meteors. When a meteor enters our atmosphere, its impact ionizes the air adjacent to it and produces an ionized trail. A meteor's passage can therefore be seen on the oscilloscope of an ionospheric recorder or a radar set. Observations of meteors by this method received extensive publicity last October because of the striking advantage of this method of observing them when clouds screen them from sight. Radio reception on frequencies above

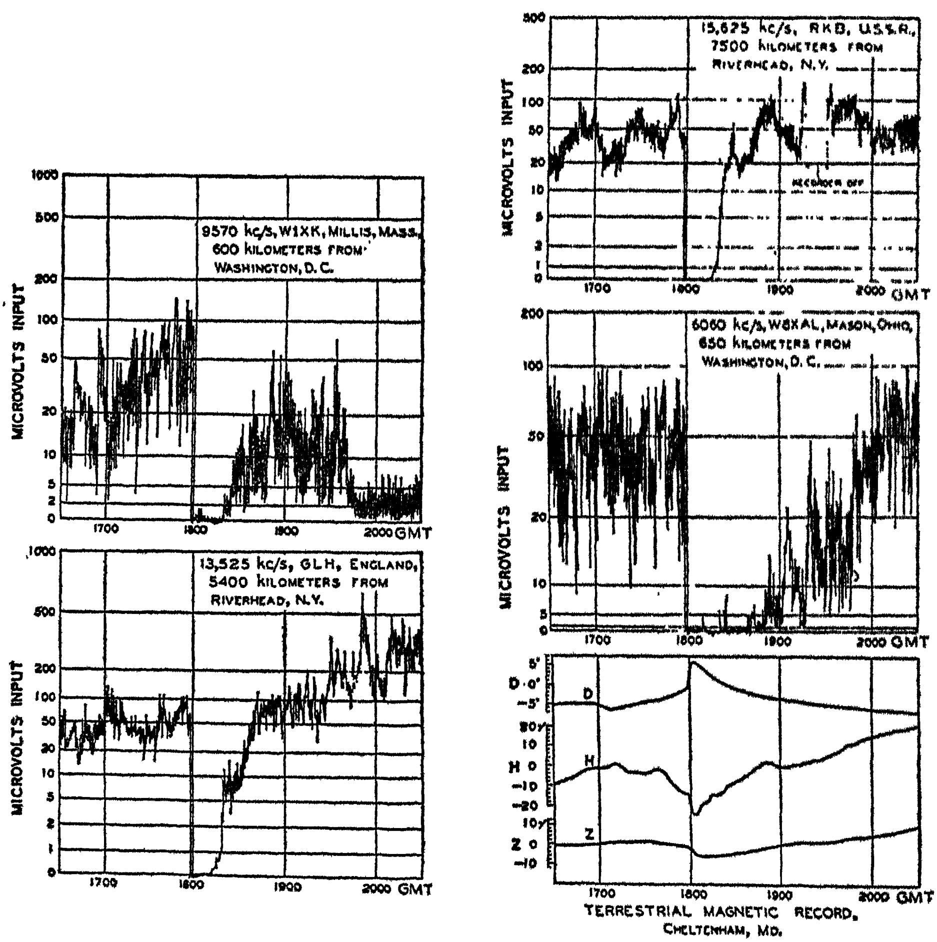


FIG. 9. SUDDEN DISTURBANCE OF THE IONOSPHERE ON MAY 28, 1936

AS REVEALED BY RADIO FADE-OUT AND TERRESTRIAL MAGNETIC PERTURBATION.

40 Mc. is sometimes subject to interference by short bursts of transmission from a very distant station, and these bursts of interference are, in some cases at least, caused by reflection from meteor trails. It is possible that the more continuous type of ionosphere ionization known as sporadic E is in large measure caused by meteors.

actual sunspot numbers. It is convenient to retain the sunspot number terminology, although the ionospheric sunspot number is much more fruitful than the actual sunspot number as a basis of comparing various phenomena affected by the sun.

Since the monthly CRPL predictions of ionospheric conditions are made five months

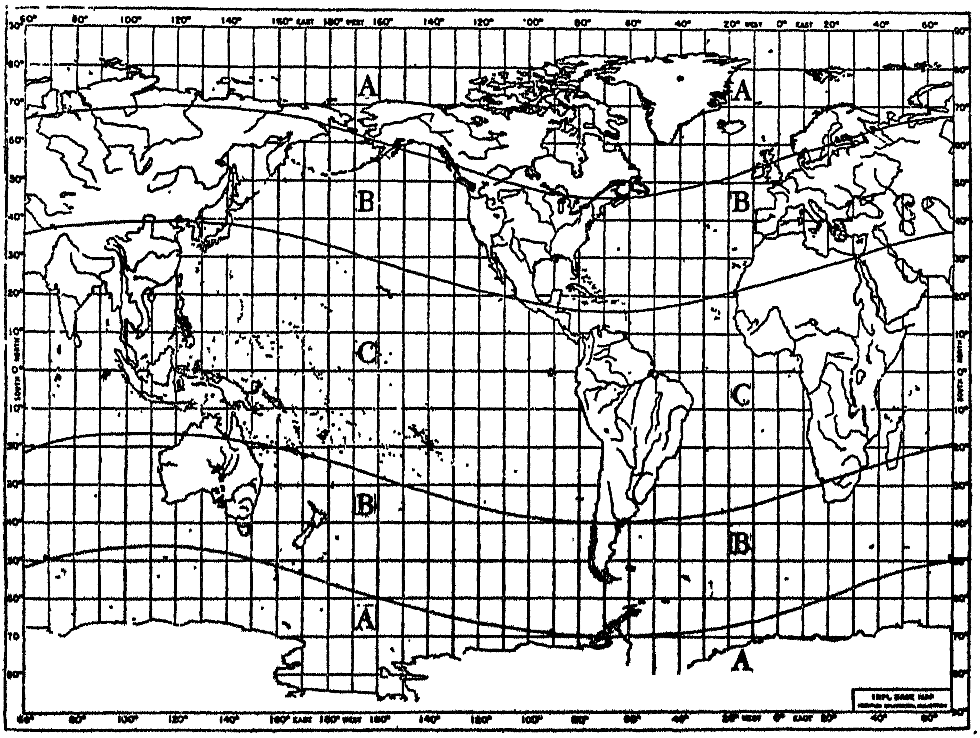


FIG. 10. WORLD ZONES FOR RADIO DISTURBANCE FORECASTS

Reverting to the more regularly predictable ionization conditions caused by the major flow of ultraviolet radiation from the sun, the close correlation of the ionization of the ionosphere with sunspot number has been mentioned. Analysis has shown that ionospheric measurements of critical radio frequencies are a considerably better index of fundamental solar activity than sunspot numbers themselves. An equivalent, or ionospheric, "sunspot number," calculated from critical frequencies, presents a smoother and more reliable graph than

in advance, it is necessary to estimate the probable value of the sunspot number at the time for which the predictions are made, in order to take into account the established relationship between ionospheric conditions and sunspot numbers. A simple system for forecasting sunspot numbers some months in advance has been developed at CRPL and used for this purpose. It is based on the average correlation between sunspot numbers in successive years. Predictions of sunspot numbers by this method at 3-month intervals one year in advance have had an

average accuracy of three (on the sunspot number scale) for six predictions during the cycle now in progress. It is unlikely that this high accuracy will be maintained, since the error limit, estimated from preceding cycles, exceeds this figure, the probable error of a prediction for one year in advance averaging slightly over seven on the sunspot number scale.

The principal emphasis to date in the study of the ionosphere has been upon practical use of the data in the forecasting of radio transmission conditions. There has not been entire neglect of the utilization of this great body of data in determining the basic properties of the atmosphere or the nature of the physical processes by which solar events control these properties. The ionosphere, the extreme outer envelope of the earth, is recognized as a strategically situated radiation laboratory. The principal laboratory tools are radio waves, recordings of geomagnetism and aurora, meteors, and, more recently, rockets. Data from this planetary laboratory will increasingly reveal the physical condition of the outer atmosphere, its temperatures, densities, mean free paths, recombination processes, geomagnetic circulation, and may also lead to information on air circulation and other phenomena in the lower atmosphere (stratosphere and troposphere). As an astronomical laboratory the ionosphere is perhaps even more interesting. The statistical studies of the regular radiations from the sun, revealed in the regular ionosphere characteristics, the observations of radio and geophysical anomalies associated with the irregular solar outpourings of radiation and particles, and stellar and solar noise measurements have taken their place alongside spectroscopic studies as powerful means of increasing the intimacy of our acquaintance with extraterrestrial events.

Despite the extensive work already under way, ionospheric and related research are only beginning; countless lines of profitable work need further cultivation.

WEALTH DIFFERENCES IN A MEXICAN VILLAGE

By OSCAR LEWIS

Dr. Lewis (Ph.D., Columbia, 1940) is Assistant Professor of Anthropology at Washington University. Prior to the war he taught at Brooklyn College and was a Research Assistant at Yale. During the war he was employed with various government agencies doing research in rural areas of the United States, Cuba, and Mexico. The material for this article was gathered under the auspices of the Inter-American Indian Institute, Mexico City. In June Dr. Lewis returned to Tepoztlán to complete his study.

ANTHROPOLOGISTS have long noted the existence of wealth differences in so-called primitive or folk societies and have recognized that there is some relationship between the distribution of wealth and the social structure. However, the absence of quantitative studies of wealth differences has impeded a fuller understanding of the role of wealth and has limited the scope and quality of our analysis of the economics of other societies. In this connection anthropologists might well learn from rural sociologists who, in their studies of rural groups in our own culture, use quantitative data on property ownership, particularly land, as a starting point in their analysis of rural society. The need for this type of data in anthropological studies has been explicitly recognized in recent years by a number of anthropologists.

I think it is worth while to consider briefly why there have been so few quantitative studies of wealth differences. One reason has been the tendency to assume that nonliterate societies are simple and homogeneous and that the study of wealth distribution would not be especially revealing. Another reason is that many anthropologists have frankly not been interested in the field of economics. But even for those anthropologists who have been aware of the need for more precise data on wealth distribution there are serious obstacles of a practical field-work nature. The sheer amount of time and work required for gathering the necessary economic data—for measuring plots of land, for determining land productivity, and for obtaining property inventories on hundreds of families—presents a discouraging if not impossible task, especially for the traditional lone anthropologist who goes into the field as a one-man expedition of all the social sciences, eager to get a bit of everything.

It is the purpose of this article to report the results of an effort to study quantitatively the wealth differences in the Mexican village of Tepoztlán and to present a scale devised to measure these differences. The data set forth here were gathered in the village of Tepoztlán over a seven-month period from December 1943 to June 1944, with the assistance of Mexican students and professional agronomists. It will be recalled that this village had been studied seventeen years earlier by Dr. Robert Redfield.

Tepoztlán is located about 18 km. from Cuernavaca on the escarpment of the Ajusco Mountain Range at an altitude of about 5,000 feet. It is a village of approximately 3,580 people (as of 1944), distributed in 853 families. The population consists of peasants, artisans, and merchants, but the village is primarily agricultural, and most of the merchants and artisans are also part-time farmers. Tepoztlán is the *cabecera*, or "seat," of the *municipio* of the same name, which consists of seven smaller villages, all within a radius of less than four miles. The country is hilly and forested, and the land is poor. Less than 25 percent of the total land area of the village is suitable for cultivation. The remainder is in forest or pasture, both of which are communally owned.

Our first step in the study of wealth differences was to determine how wealth was defined by the villagers. Invariably, *los ricos*, or "the wealthy," were described as "those who own much land and cattle." Private land ownership (in contrast to *ejido* holdings) was considered the single most important form of wealth. It is the goal of each family to own land; artisans and merchants invest in land when they can. Cattle and oxen rank next in importance as forms of wealth. In all, twelve items were most frequently mentioned by informants as forms of wealth in the village. These were *ejido* plots, privately owned land, team of oxen, plows, cattle, burros, mules, horses, hogs, sewing machines, urban property (i.e., the ownership of more than one house site and house in the village), and plum trees (*S. lutea* or a related species). Of these items we need note here only that they are all means of production and a source of income. The sale of plums, for example, is an important source of income for many families, particularly since the building of the road in 1935.

How are these items of wealth distributed among the 853 families of the village? Let us begin with land. There are three types of land tenure in Tepoztlán. First, there is privately owned land, which can be bought and sold. Second is the *ejido*, which is granted by the Departmento Agrario to the village and then by the local Ejido Commissioner to an individual family. This land can be held by the family as long as the land is being used. It can be inherited by the succeeding head of the family but cannot be sold. Third is *tlacolol*, which refers to the land on the rocky and wooded mountainsides that form part of the municipal land and which can be cleared and planted by any Tepoztecan. *Tlacolol* is not considered a form of wealth; on the contrary, it has traditionally been viewed as the last resort of the poor.

We found that 311, or 36 percent, of the 853 families own land. Two hundred sixty-seven families, or 31 percent, hold *ejido* grants. Of these, 158 families have only *ejido* grants, and 109 own their private land in addition. Thus, in a village where the ideal is for each family to own its own plot of land, we find that 64 percent of the families own no private land, and 46 percent have neither private land nor *ejido* holdings.

The size of privately owned holdings is given in Table 1.

The striking thing about the land holdings is their extremely small size. This table

TABLE 1

Size of holding	No. of owners	Percent
Less than 1 hectare........	109	36.2
1–4	97	32.2
5–9	67	22.2
10–14....................	18	5.9
15–19....................	4	1.3
20–24....................	4	1.3
25–29....................	2	.66

shows that 90.6 percent of all private holdings are less than 9 hectares in size, and 68.4 percent are less than 4 hectares. The largest holding is only about 27 hectares, and there are two such cases in the village. A man with 10 or more hectares is a relatively large landholder. Over 36 percent are less than 1 hectare. *Ejido* holdings, too, are small—95 percent are less than 3 hectares in size. When we remember that 384 families own no land at all and have no *ejidos*, the essential land poverty of the villagers is revealed.

Let us now consider the ownership and distribution of cattle. Only 180, or 21 percent, of all families own cattle. Well over 50 percent of these own between 1 and 3 cows; about 40 percent own between 4 and 10 cows. The largest herd, which is owned by the wealthiest man in the village, consists of 70 head.

The distribution of two other items, namely, oxen and plows, also tells us a great deal about the agricultural economy. There are 179 families who own a team of oxen,

and 213 families own plows. Thus, of the 469 families who own land or *ejidos* or both, over 63 percent own no oxen with which to work their land, and 52 percent own no plow. The families who own oxen therefore do a great deal of custom work, from which they realize a good income.

In order to rank the families according to their wealth, we devised a point scale using one point for every 100 pesos of value. Points were assigned to each of the items in accordance with the approximate sale value or the approximate production value or both. Thus, one hectare (approximately 2.4 acres) of *ejido* land was assigned 3.6 points because the average annual production of one hectare of *ejido* land in Tepoztlán as of June 1944 had a market value of 360 pesos. On the other hand, one hectare of privately owned land was assigned 7.2 points, which represented both the value of production and the sale value.

We were tempted to assign points for prestige value, such as in the case of privately owned versus *ejido* land, but to avoid further complications this was not done.

The items of the scale and the assigned points for each item are given in Table 2.

TABLE 2

1 hectare *ejido*	3.6
1 hectare private land	7.2
1 team of oxen	7.2
1 plow	0.7
1 cow	3.1
1 donkey	1.5
1 mule	3.0
1 horse	2.5
1 hog	1.5
1 sewing machine	3.5
urban site & house	7.5
1 plum tree	1.0
nonfarm occupation	1.0 for every 100 pesos earned annually

A score was obtained for a given family by adding the number of points which it obtained for each item. For example, if a family owned 4 hectares of land (the minimum size of holding considered necessary by Tepoztecans for a "decent living" for a family of five), 1 plow, 1 team of oxen, 1 horse, 1 cow, 2 hogs, 2 plum trees, and a sewing machine, it would receive a score of 47 points. Since this is a very modest list, even according to Tepoztecan standards, a score of 40 to 50 points may be taken to represent approximately the minimum in property ownership necessary for a self-sufficient farm family. The distribution of scores is presented in Table 3.

The most significant features in this frequency distribution are (1) the extremely wide range of wealth differences from zero to over 400 points; (2) the great majority clustering around the lower end of the scale,

TABLE 3

FREQUENCY DISTRIBUTION OF 853 FAMILIES ON ECONOMIC POINT SCALE

Score	No. of families	Percent of total	Subgroup	Percent of total	Large group	Percent of total
400–407.4	1	0.11				
220–253.0	3	0.35				
200–219	2	0.23				
190–199	1	0.11	B	1.5		
180–189	1	0.11				
170–179	3	0.35				
160–169	2	0.23			III	4.4
150–159	3	0.35				
140–149	3	0.35				
130–139	5	0.58	A	2.9		
120–129	4	0.46				
110–119	4	0.46				
100–109	6	0.70				
90–99	16	1.87				
80–89	18	2.11				
70–79	17	1.99		13.9	II	13.9
60–69	20	2.34				
50–59	28	3.28				
40–49	20	2.34				
30–39	74	8.67	B	21.6		
20–29	111	13.00				
10–19	206	24.15			I	81.5
1–9	213	24.02	A	59.9		
0	92	10.78				

indicating widespread poverty (note that 81 percent of the families have scores below what we have tentatively designated as a minimum for decent subsistence); (3) the 92 families having a zero score, and (4) the manner in which, from the distribution of the scores, the families fall into distinct economic groups. Eighty-one percent of the families are in the lowest group (point score 0–39); 13.9 percent are in the middle group (40–99); and 4.4 percent are in the upper group (100–407.4). The lowest group can be broken down into two subgroups, from 0–19 and 20–39, which we shall call I-A and I-B, respectively. The middle group will be referred to as Group II, and the upper group as III-A (100–159) and III-B (160 and over).

To test the validity of our groupings we asked ten informants to name the ten wealthiest families in the village. All those named were in our top group. Another way in which we checked our scale was to present names selected from each of the economic levels of the scale and ask informants to rank them according to their wealth. Again we found a very high correlation.

What are the characteristics of each of these economic groups? First let us consider the families with zero scores. For the most part they are either young married men, most of whom live with their parents, who also have low scores; or they are widows or old men, many of whom live alone. One-third of this group are women, who manage to earn a living by small-scale trade and by doing odd jobs.

Group I-A, which consists of 511 families with scores from zero to 19, contains 97 percent of the landless people in the village. Three hundred fifty-four, or 70 percent, of the families in this group have zero score for land. How do these landless people live? Approximately one-third depend upon *tlacolol*, but all depend upon a variety of activities which together provide only a meager income. Thus, many burn charcoal, sell wood, work as peons, are small traders, or have some other part-time occupation. They have some measure of security in that most of them own their houses and house sites or will inherit them. About one-fourth of them plant some corn around their houses and about 40 percent have some income from plum trees. About one-third have hogs. Less than one-third own a mule, horse, or donkey, which are so essential for work and transportation.

The families in Group II include most of the artisans and merchants as well as better-to-do farmers. The former are the most acculturated group in the village. They are the ones who wear store clothes, who send their children out of Tepoztlán to high school, and who generally have a higher standard of living.

Group III consists of 38 families, all of whom have high scores on land or cattle or both. About one-half of these families have inherited their land from wealthy relatives who before the revolution were *caciques* and dominated the village. The other half have worked their way up to their present position.

One might ask whether there is any relationship between position on this scale and standard of living. Do the wealthiest people have the highest standard of living? This cannot be answered categorically. On the whole, the people in Group III consume more meat, milk, eggs, and bread, and they generally live in better-constructed and better-furnished houses, some of which have running water. However, they are not the ones who go in for modern dress or any ostentatious spending for comforts or luxuries. They are a hard-working people and not a leisure class. One of the distinguishing characteristics of this group is that they generally have hired men all year around, but, with the exception of two men, they work side by side with their peons.

What is the relationship between

wealth and the adoption of new traits? The Mexican census of 1940 included three interesting items which provide us with some data on acculturation in relation to standard of living. The questions were: Do you eat bread (as against *tortillas*)? Do you wear shoes (or go barefoot or wear huaraches)? Do you sleep on a bed or a cot (or sleep on the ground or on a *tepexco*—a raised frame upon which the *petate* is placed)?

From a special tabulation of the census of Tepoztlán, we were able to correlate the responses to these questions with the family position on the economic scale. The results are shown in Table 4.

It is clear that eating bread correlates positively with economic position. Thus 23 percent of the people in Group I-A as compared with 57 percent of the people in Group III-B ate bread. Furthermore, we know from our observation that the wealthier people eat bread more often and in greater quantities. The point is that bread is still a luxury item in this village.

Wearing shoes and sleeping in beds do not correlate with wealth, but rather with age.

TABLE 4

Group	Percent who eat bread	Percent who wear shoes	Percent who sleep on bed or cot
I-A	23.20	6.46	14.12
I-B	32.30	6.78	23.18
II	50.82	12.06	30.71
III-A	41.55	7.14	21.42
III-B	57.69	5.12	16.66
Tepoztlán as a whole	31.18	7.41	19.29

That is, the older people, whether rich or poor, prefer to use huaraches or go barefoot and to sleep on the traditional *petate* or on a raised *tepexco*. We have here a nice example of the factor of selectivity in the adoption of new traits. Families who do not use shoes or beds will often buy sewing machines. For example, whereas only 6 percent of Group III use shoes, 70 percent own sewing machines.

It should be noted that a larger percentage of the middle group—Group II—have adopted new traits, even though their economic resources are less than those of Group III.

There remains only for us to discuss the age factor in relation to position on this scale. Table 5 shows the frequency distribution of the age of heads of families by economic categories.

TABLE 5

AGE DISTRIBUTION OF HEADS OF FAMILIES BY ECONOMIC GROUP

Group	Below 29 yrs.	30–49 yrs.	50–69 yrs.	70–99 yrs.	Total
0	31	31	18	12	92
I-A	63	194	132	30	419
I-B	6	88	77	14	185
II	3	46	52	18	119
III-A	0	9	15	1	25
III-B	0	1	11	1	13
Total	103	369	305	76	853

It is apparent that there are no younger people in the upper group and very few in the middle group. The bulk of the younger people are at the low end of the scale. Conversely, the wealthiest are of an advanced age, mostly between fifty and sixty-nine years of age. Forty-one percent of the heads of families over age fifty are in Group I; 59 percent are in Group II; and 74 percent are in Group III. But while there is a positive correlation between wealth and old age, the converse is not true. The fact that 41 percent of the older people are in Group I shows that vertical mobility is quite limited. The practice of not dividing up the property until the death of the parents often results in adult married sons with as many as five children being entirely landless and without a house.

Our point scale, although not a refined statistical instrument, has revealed a much

wider range and a less equal distribution of wealth than one might anticipate for a community of this type. With this scale we can determine the relative economic status of every family in the village. We are therefore in a position to study such things as leadership, marriage, the *compadre* system, and standard of living in relation to economic status. We believe that if a similar scale were used in studies of other societies, adapted to local conditions as necessary, we should have a much better basis for comparative analysis of the role and distribution of wealth.

THE SHELL

In my hands are the lives of millions—
Never forget that;
O yóu who hug the earth beneath my whisper
In the stark night,
Know that I am pain and death,
Madness and fear unending;
You who shudder in the hollows,
In the dugouts, the foxholes, and under cliffs of earth,
Remember me:
I will find you out . . .
And all the bright hopes of man,
The memories, desires, plans, the thousands of words—
Will fade in my whisper
That grows to a shout,
That crashes and overthrows
Man's world.

DANIEL SMYTHE

X-RAYING THE PERSONALITY: AN INTERPRETATIVE EVALUATION OF TWO PROJECTION TECHNIQUES

By LOUIS WEKSTEIN

Dr. Wekstein (D.Sc., Portia College) is Professor of Psychology at Calvin Coolidge College, Boston, and a consultant psychologist in the city of Boston. He is also engaged in applying the projection techniques in psychosomatic research at the Massachusetts General Hospital. After graduating from Harvard he was a pianist and writer before returning to psychology.

FOR many years the clinical psychologist has gazed with undisguised awe and envy at that highly prized instrument of the physician, the X-ray. True, the psychologist did have at his disposal a number of instruments for arriving at a diagnosis of the personality, but these techniques lacked the well-defined clearness, the depth, that is associated with the all-powerful X-ray.

Intelligence tests such as the Stanford-Binet, and especially the Wechsler-Bellevue, can yield fruitful information about the personality structure in addition to the intellectual status—the I.Q. score—when they are administered and interpreted by a competent psychologist. Personality inventories, aptitude tests, association tests, and interviews serve to supplement the data secured from intelligence tests.

Nevertheless, the thoughtful psychologist occupied with diagnosis has felt, and rightly so, that none of the above methods gives a clear, integrated picture of the total personality, that none of the above techniques is sufficiently penetrating, either individually or collectively, to take into account the numerous factors involved in the subject's mode of perceiving.

The central core of the perceptual process is meaning, and it is vital for the psychologist to ascertain the individual's meanings, his way of seeing life, his modes of reacting to reality, his emotional life, and the strength of his drives and needs.

In short, it is the purpose of the psychologist to study and evaluate the dynamic interplay of forces operating in the individual. Moreover, he must accomplish this purpose in the shortest possible period of time. The average person who presents himself for personality evaluation for one reason or another has neither the time nor the financial resources for extended observation. Also, the time the psychologist is able to spend with each subject is limited.

Unfortunately, the standardized tests mentioned do not meet the above requirements. It has been found only too often, after spending two to three hours administering intelligence tests, personality inventories, and aptitude tests, that relatively little truly significant material has been revealed about the subject.

For example, the tests may reveal that the subject is superior in intelligence; that his reasoning and language ability are good; that his rote and logical memory are on a high level; that he is more successful on verbal than performance portions of the scale; that he is extroverted, inclined to be ascendant, cooperative and pleasant in his manner and speech; and that he has many theoretical interests. Despite this description, we know precious little about this subject. He might be a happily married, kind, and moderately successful businessman, he might be a university professor of chemistry, an avid reader of THE SCIENTIFIC MONTHLY, or he might be a maladjusted and dangerous killer.

Only by eliciting a more comprehensive imprint, only by the inclusion of a greater number of facets and nuances of the personality structure, can our subject with the superior intelligence be understood as a

living, adjusting, striving, reacting organism.

During the past two decades, psychologists have been turning in increasing numbers to research toward just such an end, and a number of tests designated as projection techniques have come into use. Some of these tests have been so effective in yielding fruitful clinical data and so valuable in revealing the inner structure of the personality that they might well be referred to as X-ray techniques. Today every mental institution, guidance center, and clinic worthy of the name makes use of these tests. Schools, colleges, the armed forces, and numerous progressive organizations that find it necessary to evaluate personalities have followed suit.

Projective methods of examination are quite unique. The subject is confronted with an unstructured test situation. The term "unstructured" refers to the fact that the materials utilized in the test situation and their relationship are not strictly defined. The subject is instructed to follow his own inclinations in responding to the stimulus material. He is thus free to handle and to interpret the situation in any way that he wishes. He is free to organize the material as it would please him. There is no "right" answer. No two subjects organize the test material in precisely the same manner because there are no two identical personalities. Each subject projects his own individual picture, his own individual X-ray.

It is both interesting and instructive to contrast projection methods with those followed in intelligence tests. In the intelligence test the subject is given little or no leeway. He is expected to react to the stimulus material in one way—the prescribed, correct way. The test situation is thus structured. The standardized tests, as L. K. Frank points out, rate the individual in terms of how nearly he approximates to the acceptance and use of culturally described patterns of belief, action, and speech.

The projection techniques, on the other hand, offer the subject a plastic medium, a film, so to speak, on which he can project his mode of perceiving, his meanings and feelings. The imprint that the subject leaves on this film is an X-ray which the psychologist can interpret.

This discussion will be limited to a descriptive evaluation of two of the most valuable projection techniques in general use today, the Rorschach Ink-blot Test and the Thematic Apperception Test.

THE Rorschach test takes it name from its creator, Hermann Rorschach, a brilliant Swiss psychiatrist and research scientist. The test was the result of ten years of experimentation on his part. The stimulus material of this diagnostic procedure—the "film"—consists of ten ink blots that were selected from thousands of trial blots. In five of the blots, colored ink is used in addition to black ink.

These ink-blot cards were originally published as part of *Psychodiagnostics*, Rorschach's monumental contribution to psychology. Rorschach considered *Psychodiagnostics* as merely a preliminary outline of his thesis. Unfortunately, his premature death at the age of thirty-seven interrupted his amazing researches. His colleagues in every part of the world, however, continued his work, amplifying it and filling in gaps.

Dr. Nolan D. C. Lewis, Director of the New York State Psychiatric Institute, writes as follows in a brief preface to Klopfer and Kelley's *The Rorschach Technique:*

> The Rorschach method is remarkably effective in estimating the intellectual status of an individual; in revealing the richness or poverty of his psychic experience; in making known his present mood, and in showing the extent of his intuitive ability as well as in disclosing his special talents and aptitudes. By virtue of its unique function in these areas, the value of the technique is becoming increasingly clear to psychologists in social service work, personnel administration and vocational guidance.
>
> In psychiatry, the validity of the method as a diagnostic instrument has been established. It

points the way to new understanding of mental disorders and it has gained a reputation for its service in identifying borderline cases and in differentiating among psychoses, neuroses and organic brain disorders. Because the method differentiates reliably between normal groups with varying personality traits and subjects with mental disorders, it is finding a use in the U.S., Canadian, British and German armed forces for the detection of the unfit. Here as elsewhere it detects anxieties, phobias and sex disturbances, as well as more severe disorders and serves as a guide for appropriate treatment. . . .The limits of the research possibilities of the Rorschach method are not yet in sight.

The test is administered in the following manner: The subject is comfortably seated at a table or desk with the psychologist seated a bit behind. This arrangement makes the subject less aware of the psychologist, who is to be a witness to these projections. It should be mentioned that in certain cases, however, it is necessary to face the subject to secure the best results.

As the next step in administration, some psychologists simply hand the subject the first ink blot and ask, "What do you see here?"

Whether this direct technique should be followed or whether a few words of explanation are in order again depends on the subject. A curious or an insecure, inhibited person may require encouragement as well as explanation. I have found that resistance can be easily overcome in such subjects by the use of a short preface such as this:

You've probably played with ink blots as a child. You drop ink on a paper and then you fold the paper and squeeze. That's how this test was constructed. The blots were specially chosen from thousands of trials. Now I'm going to have you look at ten such blots one by one and I want you to tell me what you see, what each blot means to you. There is no right or wrong, so you can feel perfectly at ease. This will give me a good idea of your imagination.

Even if no reference to imagination is made, subjects invariably regard the test as an investigation of fantasy. As Rorschach has pointed out, this does not affect the outcome of the test. Those subjects who are not imaginative cannot become imaginative because they believe the test to be one of fantasy. Those who are imaginative prove it. Actually, the interpretation of the ink-blot configurations falls in the field of perception rather than imagination: therefore, whether the individual be imaginative or be lacking in imagination means little, and those subjects who may be lacking in fantasy reveal the inner structure of their personalities just as clearly through their projections—through their perceiving powers—as those with a rich fantasy life.

The Rorschach test is unquestionably the most complicated test in the field of clinical psychology. To the layman and the novice, scoring elements appear particularly involved and confusing. Actually the administration of the test takes between thirty minutes to an hour in most cases. The interpretation of the data, of the "X-ray," may require a full day's concentration. Obviously, the Rorschach interpreter must be extremely well versed in psychopathology.

The psychologist, after handing the ink-blot card to the subject, notes the time required for the subject to give the first response to each card. How long it takes the subject to give his first response is quite significant in that his reaction time to cards with color and shading can be compared with those cards that are achromatic and have little shading.

Every response that the subject gives to the ten cards is carefully recorded. Few responses, many responses, or failure to respond to one or more of the cards is of diagnostic significance.

Psychoneurotics present different patterns of responses than schizophrenics or normals. Extroverted people respond quite differently than rigidly repressed introverts. For example, one subject may describe Card I as a huge bat, another may notice a veiled human figure where the first saw the body of the bat, and to a third subject the card may represent two Teutonic knights about to swoop

down on a knave with upraised hands. How are such responses evaluated and differentiated from one another? What diagnostic significance can be attached to the incidence of a particular type of response?

Three categories operate in analyzing a response: the location, the content, and the determinant. Every scorable response must have a location, a content, and a determinant. The relationship of the various categories is carefully studied, and their ratio is represented mathematically. The location and content of the response are relatively easy to ascertain, although the determinant may prove more difficult. These categories will be considered in their order.

The location refers to that portion of the ink blot that the subject has selected for his interpretation. Letters of the alphabet have been designated to symbolize the type of location response. If a subject uses the entire blot, it is scored as a whole response, *W*. If a large or frequently seen, obvious portion is selected, it is scored as a detail response, *D*. If a small, unusual, or rarely seen portion of the blot is chosen for the answer, it is scored *Dd*. If the subject chooses a white space rather than black or colored portions of the blot, the response is scored for space, *S*.

The absolute number of *W*, *D*, *Dd*, and *S* is not so important as their ratio to one another. *W* represents the tendency to organize and involves integrative ability. Subjects who are intelligent are able to produce more than seven good *W*'s. The feebleminded give few *W* responses, as do subjects who suffer from mental deterioration. *W* then is an indication of the theoretical, of the abstract, the original, and the creative tendencies. Many *W*'s are found in the protocols of talented subjects. It should be noted that there can be poor *W*'s—*W*'s poorly perceived. Confabulated *W*'s may indicate mental illness. The good *W* must have clearly perceived form accompaniment.

The *D* responses are most frequent. They represent the common-sense, realistic element and are a sign of practicality. People who give a preponderance of *D*'s (in relation to *W*'s and *Dd*'s) are reproductive rather than productive. They are down-to-earth people who see the obvious and are not particularly concerned with theory.

Preoccupation with rare, unusual details—the *Dd*'s—speaks for itself. Such subjects are very meticulous and precise. They are absorbed by the minute. In the extreme, such a person would be a faultfinder, a nagger, a precisionist.

S responses indicate oppositional tendencies. These tendencies may be expressed against the milieu or directed to the self. This negativism may be emotional or intellectual. Other factors in the test must be considered before the *S* response can be truly evaluated.

Rorschach considered a distribution of approximately 25 percent *W*'s to 65 percent *D*'s to 10 percent *Dd*'s and *S*'s as optimal. However, it must be emphasized from the gestalt point of view that all the factors involved must be considered in relation to one another. The parts cannot be divorced from the whole, and there are many exceptions to this optimal distribution.

It is obvious, then, that a well-adapted, intelligent person will give a good ratio of *W*, *D*, and *Dd* responses. An individual with a huge preponderance of *W*'s, with few *D*'s and *Dd*'s, would be the highly abstract, theoretical type, very impractical, and uninterested in anything detailed. The university professor is often caricatured as such a type.

In the schizophrenic personality there is frequently an emphasis on *W* and *Dd*. These people do not see the obvious and they are ill.

An overweight of *D* and *Dd*, on the other hand, although not pathological, indicates the very practical realist who runs away from theory. Although this may be quite

desirable in certain occupations, such people find liberal arts courses (especially in philosophy) incomprehensible.

Every response must be scored for content in addition to location. Subjects frequently see animals, human figures, objects, plants, anatomical content, landscape, geological content, and clouds in the blots.

The average subject gives between 35-50 percent animal responses. Less intelligent people with more stereotypy show a higher percentage of animal responses. Very imaginative individuals give less than 35 percent animal responses. Young children and older people tend to show high animal percentage. The young and the old are more stereotyped.

Human responses connote an interest in fellow beings. Subjects who give more human parts than complete figures are interested in their fellows, but it is an anxious preoccupation. Many anatomical responses from an individual who is not a physician (and even in the cases of some physicians) indicate hypochondriasis.

The third category for which each response is scored is the determinant. In searching for the determinant, the psychologist seeks to ascertain what prompted the subject to elaborate on a specific blot or portion of a blot. What prompted the subject to attach significance to this or that part? Four main areas operate here: form, movement, color, and shading.

The form, that is, the shape of the blot area, may determine the response. For example, the subject may give the bat response to Card V, then point spontaneously and outline the head and body and wings of the bat. Such an answer has clearly been determined by the form of the ink blot.

The problem of the psychologist in scoring is to decide whether the form is accurate or inaccurate. Both Rorschach and Beck feel that if enough subjects see a particular design, it is good form (*F* plus), on a statistical basis. If the psychologist is in doubt about the accuracy, he may ask the subject to elaborate and clarify the response in the inquiry that is held subsequent to the administration of the test.

It has been found that form is related to emotional control. The higher the *F* plus percentage, the better is the subject's control over his emotions. The subject with 100 percent *F* plus has too great a control over his emotions. He permits them no expression. In this group we find the overrational person, the pedant, the restrained, the inhibited person, the individual who is afraid to permit his feelings any outlet. Depressed patients frequently indicate their repression and self-restriction by such high *F* plus percentage. In a number of cases, brain diseases may be responsible for such restriction. The optimal percentage for normal subjects has been found to be 80–90 percent *F* plus.

The percentage of good form responses has also been found to correlate with intelligence. (It should be noted that the intelligence level is not solely determined by form percentage, for the number and quality of *W* responses already discussed, movement responses, original responses, and a variety of other factors are contributory.) It has been found, however, that subjects below 70 percent *F* plus are intellectually inferior. Morons, imbeciles, paretics, and senile dements fall in the 0–60 percent *F* plus level.

Movement can also be the determinant of a response. A response is scored *M* if in addition to form perception there is also a kinesthetic element present. The movement must play a primary role, and an actual sensation of motion must be there. For example, in Card III, the response "Two gentlemen bowing to one another" is a movement (*M*) response. Frequently inquiry is necessary to determine whether the response should be scored for movement or for form.

Movement responses of humans in action

are definitely related to mental productivity and creativity. Mature, creative people of good intellectual endowment give five or more *M*'s. Movement, then, is one of the signs of intelligence and indicates a reactiveness to inner stimuli.

Since the *M* responses are a sign of rich inner life and the *W*'s are an indication of mental ability and also intellectual ambition, it is extremely interesting and important to study the relationship of *W* to *M* in the protocol. This ratio enables the psychologist to assay the degree of success that the subject has in adjusting intellectually. For example, if there are three or four times as many *W*'s as *M*'s, the subject does not show sufficient reactiveness to inner stimuli to account for his intellectual ambitions. On the other hand, an emphasis of *M*'s over *W*'s would indicate that the subject does have the endowment but is not utilizing his rich inner life to best advantage. Klopfer feels that at least five *M*'s and approximately twice as many *W*'s are optimal.

Feeble-minded people, schizophrenics, and senile dements and other deteriorated patients generally give no *M*'s. At best such people cannot give more than one or two *M*'s. (*M* is also scored plus or minus depending on how well the form of the movement is seen.)

A third possible determinant of a response is color. Color may be the primary determinant or it may appear with, and in harmony with, form.

Color responses are representations of the affective part of the subject's personality. Just as the form (*F*) answers denote the degree of restriction and inhibition, so the color answers denote the degree of emotionality. Obviously, in the well-adapted, well-socialized person there must be a balance between form and color.

Three main types of color responses have been differentiated. The first of these is color naming without form and is designated *C*; i.e.: "That's blue and that's red;" "Blood;" "Sky." This type of answer is pathological. It is never given by normal subjects. *C* answers are given by impulsive, explosive, emotionally uneven and unpredictable people.

Responses where the color is the primary determinant and the form is secondary are termed *CF*'s. Thus, in these answers the form of the blot is not disregarded; i.e., "Sunset," to Card IX.

Responses where the form is primary but the color plays a significant part in the concept are termed *FC*; i.e., "Caterpillars," for the green figures in Card X.

The greater the emphasis of *FC* over *CF*, the better adjusted, the more socialized, is the subject. Obviously, the well-integrated individual has a good control over his emotions. Responses of the *CF* variety are common for normals and only give cause for alarm when they are not balanced by a sufficient number of *FC*'s.

It is rather interesting to note that neurotic subjects show color shock, that is, they are affected by the chromatic cards. Color shock is measured by such criteria as annoyance, confusion, increased reaction time, and a number of other signs manifested in handling the colored cards. At least three criteria should be present before a diagnosis of color shock can be made.

A short time prior to his death, Rorschach discovered a fourth determinant, shading. Every card has shading elements present to a greater or lesser degree. These shading nuances, called chiaroscuro, may influence the subject in the formation of his concept. A chiaroscuro determinant is designated as *Ch*. Again, as with color, three types of *Ch* responses have been differentiated.

A pure *Ch* response is a definite indication of uncontrolled anxiety. In the *ChF* response the shading determines the answer and the form is secondary. Such responses signify general insecurity or anxiety of which the subject is unaware.

In the *FCh* type of response the subject has been primarily influenced by the form, but the shading has played a part. Such subjects are introversive, cautious, and given to introspection and self-analysis. More than three *FCh* is a sign of self-preoccupation. Shading, then, is an anxiety characteristic which may be tempered by form.

The responses are also scored for popularity and originality. Original responses are very rare—one out of a hundred. Only intelligent subjects give good *O* pluses (which stand for originality). In attempting to evaluate the subject's ingenuity and intellectual status, the percentage of *O* responses is considered an important factor.

Popular responses are those given by many subjects. They are a sign of participation, of common sense. The normal subject gives a number of them. However, just as too many original responses would place a subject apart from this world, too many popular responses would signify that he is commonplace—that he is dull and boring.

After the subject has responded to all ten cards, the psychologist may question him about his answers to specific blot areas. This inquiry may determine whether a particular response should be scored for movement or for form, whether color is primary or secondary, whether shading is primary to form, etc.

The next step is tabulating each response in the three main categories. Thus, the response "Two knights sweeping down on a knave" would be scored *W M H*: *W* because the entire blot is used; *M* because there is human action plus form; and *H* because the content is human.

After each response has been treated in this manner the *W*, *D*, *Dd* and S, *F*, *M*, *C*, etc., answers are added up and their percentages of the total are obtained.

It must be stressed that no one response will determine the diagnosis of the personality. The Rorschach expert studies the relationship of the responses to one another in the total scheme. He is interested in the configuration. The parts in themselves are misleading and frequently meaningless. As the gestaltists put it, the whole is more than mere random parts. It is an integrated cohesive totality. It is this dynamic structure that the psychologist seeks to assay.

Just as the physician is frequently called upon to reassure a patient who manifests a symptom of disease after an evaluation of his entire physical condition, so the Rorschach interpreter, while noticing signs, comes to no conclusions until he has cautiously investigated the interplay of forces of the personality.

I wish to emphasize most strongly that I am fully aware that many if not most of the brief statements made with respect to interpreting a Rorschach protocol require qualification and further elaboration. If qualification and further elaboration were attempted, this discussion would of necessity take a form far beyond its intended scope. Rorschach literature is already assuming voluminous proportions.

Actually, the Rorschach expert must be a psychologist and an experienced clinician as well, just as the roentgenologist must be a physician with a good background in anatomy, physiology, and clinical medicine. In the hands of the layman or even the well-intentioned amateur the technique is useless.

Another type of projection technique has been devised by Dr. Henry Murray, Director of the Harvard Psychological Clinic. This method, known as the Thematic Apperception Test and familiarly abbreviated TAT, has, like the Rorschach, been found to be a valuable instrument in revealing an intimate picture of the personality within a remarkably short time. Most clinical psychologists find that their Rorschach interpretation can be confirmed and can also be considerably enhanced and enriched with the administration of the TAT. As Murray

points out, the two tests yield complementary information.

The plastic material, the film for the projections in the case of the TAT, consists of a series of pictures presented singly to the subject. The subject is instructed to devise stories about the situations and characters depicted.

The value of the test lies in the fact that human beings tend to read their own meanings into the pictures. The subject externalizes, projects his own experiences, his own feelings and needs, onto the stimulus material. To facilitate the subject's identification with the characters represented, the pictures contain both men and women of various ages.

Murray has aptly expounded on the rationale of the test as follows:

> If the pictures are presented as a test of imagination, the subject's interest, together with his need for approval, can be so involved in the task that he forgets his sensitive self and the necessity of defending it against the probings of the examiner, and, before he knows it, he has said things about an invented character that apply to himself, things which he would have been reluctant to confess in response to a direct question. As a rule, the subject leaves the test happily unaware that he has presented the psychologist with what amounts to an X-ray picture of his inner self.

The material of the test consists of two sets of ten pictures—twenty pictures in all—that were carefully selected because of their effectiveness in eliciting material of diagnostic significance.

Murray found from experience that the stories are more revealing and the validity of the interpretations is increased if most of the pictures include a person who is of the same sex as the subject, although eleven of the pictures were found suitable for both male and female subjects.

An hour is devoted to each set. This would allot about five minutes per picture. It has been deemed advisable to space the two sets by a day or more in order not to tire the subject.

As in every psychometric procedure, the subject must be at ease and cooperative in order to secure the best results. Since the technique is aimed indirectly at eliciting vital material, it is the special function of the psychologist to establish rapport, a friendly relationship with the subject conducive toward this aim.

A brief explanation about the test is usually tendered the subject after he has been made comfortable, as in the preliminary to the Rorschach Test.

The exact words, Murray feels, should depend on the age, intelligence, and the circumstances of the subject. The following instructions from Murray's TAT *Manual* are generally suitable for most adults of normal intelligence.

> This is a test of imagination, one form of intelligence. I am going to show you some pictures, one at a time, and your task will be to make up as dramatic a story as you can for each. Tell what has led up to the event shown in the picture, what the characters are thinking about and what emotions they are feeling, describe what is happening at the moment; and then give the outcome. Speak your thoughts as they come to your mind. Do you understand? You can devote about five minutes to each story. Here is the first picture.

The average length of stories invented by adults, presumably if adequate rapport has been established, is approximately three hundred words. The words of the subject should be transcribed, and, although a concealed recording device is ideal, most psychologists must of necessity write by hand.

After the second set of pictures has been exhausted in the subsequent session, it has been found useful to determine the sources for the subject's narratives. Many of the sources lead back to the individual's past and may be important to the problem at hand.

Scoring the TAT is a far less formidable undertaking than in the Rorschach, and the psychologist is by no means strictly bound to Murray's rather involved scoring technique. Murray is not mandatory here and feels

that whether analysis should be in accordance with a comprehensive conceptual scheme or should merely examine a few personality traits depends on the purpose of the psychologist in administering the test.

Although psychologists have abbreviated Murray's scoring, for optimal results it is probably best to abide by his analytical and scoring techniques. A brief summary of his method follows.

In analyzing a story the psychologist's first problem is to distinguish the character with whom the subject has identified himself. For all practical purposes this character is the hero. The characterizations of the heroes should be studied for such traits as superiority, inferiority, criminality, solitariness, belongingness, leadership, and quarrelsomeness. The subject usually projects himself in the role of hero, and the traits that he assigns to the imaginary character may well apply to himself, or he may be describing his ego-ideal.

It is pertinent to observe in the minutest detail what each of the successive heroes thinks, feels, or does, and here the clinician is called upon to draw on his fund of psychopathological experience to the fullest in order to discern anything that is unusual or uncommon.

Not only is the attitude of the hero important, but the entire environmental situation must be taken into consideration. In other words, all elements which confront the heroes, whether they be physical objects or human characters, play a part in the subject's projection. The psychologist must observe whether other human beings are friendly or unfriendly, whether a particular sex is preferred, whether older figures are preferred over younger ones.

The strength of the needs that the subject ascribes to his leading characters is classified by Murray in the following manner: Responses are rated from one to five depending on the intensity, duration, frequency, and importance to the plot. For example, a mild beratement would be scored as one, whereas a violent assault would be scored as five. Thus the average and the range of variables for representative groups could be obtained by adding the score of each need for the two sets and then combining them to yield a total for each separate need. Murray scores for twenty-eight needs: i.e., dominance, achievement, destruction, sex, etc.

Since the subject places his chief characters in manifold situations during his narrative, it is important to the psychologist to determine how extreme or how temperate the subject is in creating a milieu about his heroes.

Here, too, Murray's classification of thirty kinds of environmental forces and situations (press) is utilized. The criteria for scoring would again be the intensity, duration, frequency, and general significance to the plot. For example, if the hero is exposed to a rainstorm, he is placed in a far less dangerous predicament than if he were exposed to a tornado at sea, and the psychologist would score accordingly. A partial list of press follows: affiliation, rejection, physical danger, physical injury, etc.

It is significant to examine the consequences of the narration. Did the hero dominate, or was he dominated? What stipulations are there for success and for failure? What punishment is meted out for transgression? Does the hero feel guilty, confess, reform, or does he continue unscathed? What is the relationship of happy to unhappy endings?

The following response taken from H. A. Murray's *Explorations in Personality* is illustrative of one type of narrative which the test may elicit. In Picture No. 13 of the test a boy is depicted huddled against a couch, his head bowed on his right arm. An object that resembles a revolver lies on the floor.

Some great trouble has occurred. Someone he loved has shot herself. Probably it is his mother. She may have done it out of poverty. He, being fairly grown-up, sees the misery of it all and would

like to shoot himself. But he is young and braces up after a while. For some time he lives in misery—the first few months thinking of death.

Here the possible death of the mother appears as a determinant of his present pessimism. The story is one variety of a large class of complex themes—the Tragic Love theme.

The subject who gave this response, a Ph.D. candidate, had suffered great hardships in his childhood and, in commenting on his narrative, acknowledged that it was derived from his past and that he had feared his mother might kill herself because of her struggles against seemingly insurmountable poverty.

In summary, both of the investigational methods presented here offer relatively plastic fields with unstructured or loosely structured situations. Despite the artificiality of asking an individual what ink blots mean to him or to devise a narrative about a picture, both tests are potent instruments in exposing underlying factors and influences of the subject's private world. These techniques do not exhaust the possibilities for exploring the personality by any means. The development of new tests and the elaboration and improvement in interpretation of the two tests described may still be regarded as mere beginnings in the ambitious attempt on the part of the psychologist to catch an imprint of the personality.

BACK ISSUES WANTED

The unexpected addition of more than 2,000 new A.A.A.S. members between January 1 and May 1, 1947, has led to a shortage of copies of the February and May 1947 issues of The Scientific Monthly. *The reason for this shortage is that each new member in the first six months of the year has been sent back issues of the journal of his choice. Receipt of copies of these issues from members who do not maintain permanent files will be greatly appreciated. They should be sent to: American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington 5, D. C. Postage will be refunded.* —Ed.

COPPER RESOURCES OF THE UNITED STATES

By BENJAMIN MOULTON

Professor Moulton expects soon to receive his Ph.D. from Indiana University. He is now Assistant Professor of Geography at the Florida State College for Women, Tallahassee. His primary interest is in climatology.

THE United States is unique in her position as major producer and major consumer in the world copper market. American interests control 68 percent of the copper industry of the world as well as a large share of the world's reserves. Normally, the United States produces annually about one-half of the world's copper, consumes somewhat less than half, and controls two-thirds of the production beyond the national boundaries in the Western Hemisphere. A brief analysis of these outstanding facts and their causes follows.

The physical properties of copper that enable it to be widely used are:

1. High electrical conductivity.
2. High heat conductivity.
3. Ductility.
4. Malleability.
5. Noncorrosive qualities.
6. Alloying qualities.

These qualities give to the electrical and machine industries a metal that meets most of their requirements. Copper is also available in quantities that make it economical for a wide variety of purposes.

The United States deposits are widespread, although the most important producers are located in the Western states. Arizona leads, with mines at Morenci, War-

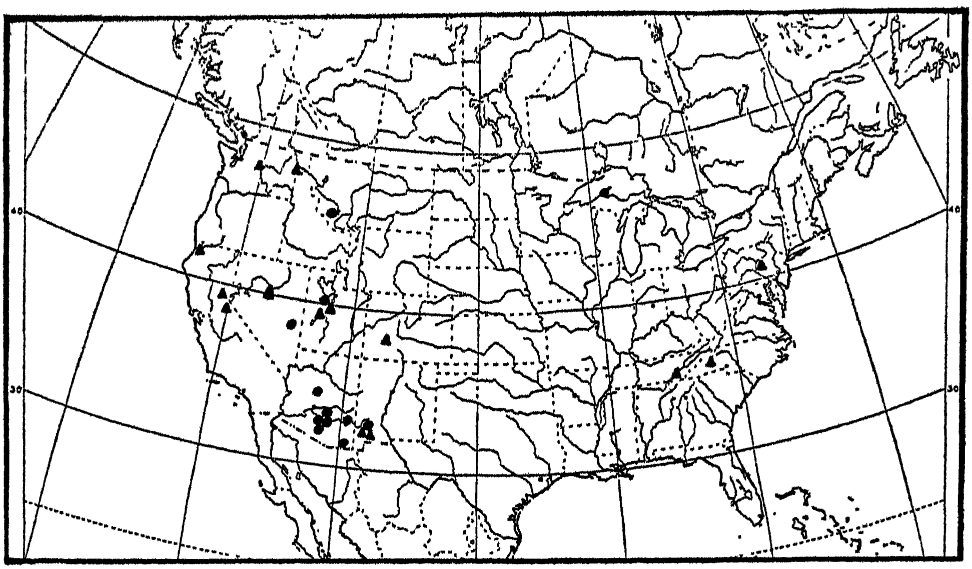


FIG. 1. THE LOCATION OF THE LEADING PRODUCERS OF COPPER IN THE U. S.

BLACK DOTS INDICATE MINES PRODUCING 10,000 OR MORE SHORT TONS OF METALLIC COPPER PER YEAR IN 1943. TRIANGLES INDICATE LESS IMPORTANT PRODUCERS. INFORMATION FROM *The Minerals Yearbook*, 1943.

ren, Globe-Miami, Ray, Ajo, Jerome, and Superior. These seven districts produce 98 percent of Arizona copper, Morenci being the leading producer. Since 1845 about one-third of the copper produced in the United States has come from Arizona.

Utah is the next largest producer of copper today; the important mines are all located in the Bingham district. These de-

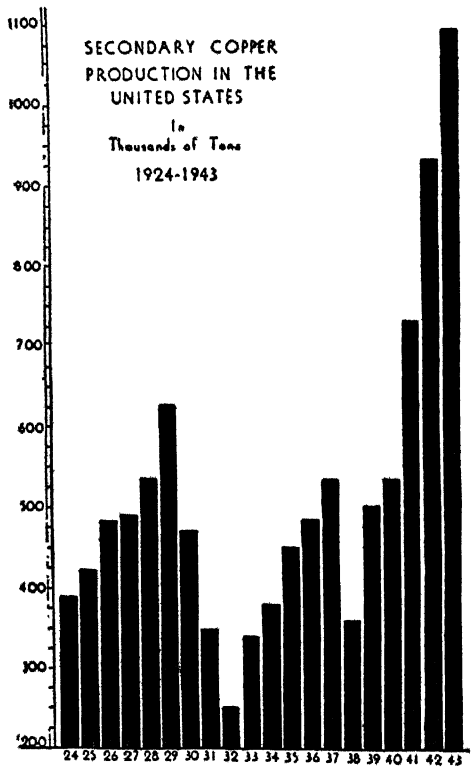


FIG. 2. SECONDARY COPPER OUTPUT

DATA DERIVED FROM NEWTON AND WILSON AND FROM *The Minerals Yearbook* OF VARIOUS DATES.

posits also yield large quantities of gold, silver, lead, and zinc as well as copper and molybdenum. The Utah Copper Mine is the second largest in the world, Chuquicamata, of Chile, alone exceeding it in reserves.

Montana is ordinarily third in copper production for the United States; a single mine in the Butte district produces more copper than any other mine in the United States.

The locations of the principal districts in this country are shown in Figure 1. Those producing more than 10,000 short tons of metallic copper are indicated by circles; those producing less, by triangles. During the war many minor producers came into operation.

Copper in the United States occurs, for the most part, in five forms—oxides, sulphides, silicates, carbonates, and metallic copper. The only metallic copper deposit of any importance is in Michigan; this deposit is becoming less accessible with the increasing depth of the mine.

An association of minerals is often characteristic of the copper deposits of the western United States, silver, gold, zinc, and lead often being obtained as by-products. The accessory minerals are not so important to the copper mining industry as a whole as to the individual mine, whose profits may depend upon them. Nevertheless, the significance of these associated minerals should not be overlooked.

The United States copper ores are low-grade, often far lower than those in other areas of the world—particularly Chile and Katanga-Rhodesia, whose ores average 2–4 percent copper. The characteristically low-grade ores have necessitated the construction of concentration mills at the mines, and nearly all copper is concentrated at the producing area.

If a map showing the location of the copper-mining areas of the world outside the United States proper were analyzed, it would be evident that the producing areas are in general quite remote from the consuming areas. Not only are they remote, but they are characteristically in geographically unfavorable areas, such as deserts or mountains. Such unsatisfactory geographic conditions have necessitated large expenditures for construction, maintenance, and trans-

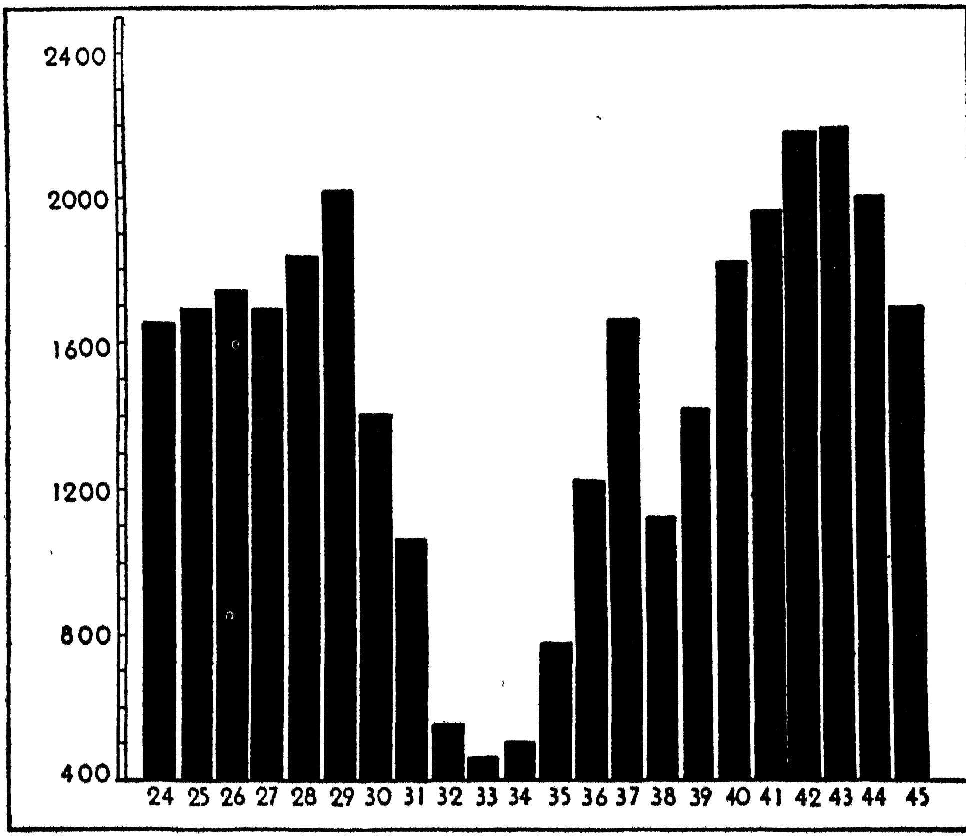


FIG. 3. COPPER PRODUCTION IN THE UNITED STATES, 1924–1945

DATA, IN MILLIONS OF POUNDS, FROM VARIOUS SOURCES; THAT FOR 1944 AND 1945 FROM *Current Business*.

portation. Outstanding examples of localities that export most of their copper are Chile and Katanga-Rhodesia.

Smelters are located in the producing area only if it is a large one, since smelters require a considerable financial outlay and are therefore constructed only where production over a long period of time makes smelting profitable.

Copper refineries, in addition to being located in regions that will insure an adequate supply of raw material over a long period of time, are found in two types of sharply differentiated areas. The older copper refineries were located in the consuming areas. A map showing copper refineries will reveal a cluster in the eastern United States, Belgium, Germany, and Great Britain. Other refineries are located in areas having ample amounts of available water power. Thus, there are refineries at Chuquicamata and Potrerillos, Chile, as well as at Tacoma, Wash., and Great Falls, Mont.

The concentration of refineries in the eastern United States (eight out of the eleven United States refineries being located east of the Mississippi) has resulted in a high degree of control by American financial interests over the copper industry. Much of the foreign ore brought to the United States is refined here and shipped without tariff payments. The amount of foreign ore

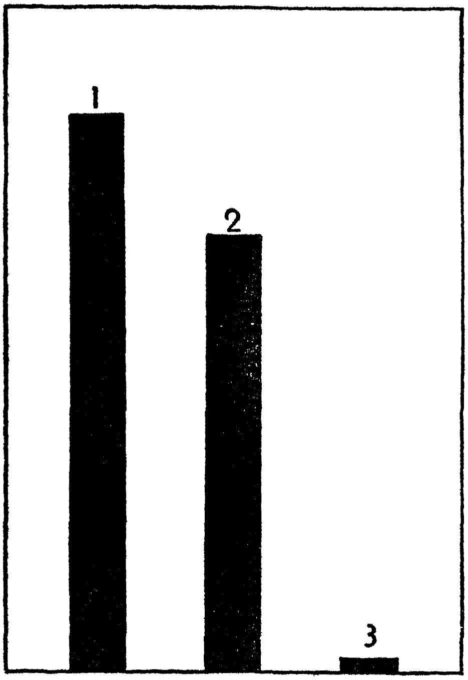


FIG. 4. U. S. OUTPUT AND RESERVES

IN MILLIONS OF POUNDS: 1. PRODUCTION, 1845–1943, 61,290; 2. RESERVES, 48,017; 3. PRODUCTION, 1945, 1,683. FROM *The Minerals Yearbook*, NEWTON AND WILSON, AND *Current Business*.

shipped to the United States is not large, however, and in prewar days most copper from foreign sources such as Chile was shipped to northwestern Europe.

The consuming centers for copper are near the group of older refineries, the largest centers being in northeastern United States and northwestern Europe. These consuming centers are near areas of machine and instrument manufacture, and a brief study of the major uses of copper would show that the greatest users of copper are the electrical and automobile industries.

The status of the copper industry in the United States is depicted by the four graphs (Figs. 2, 3, 4, and 5). An analysis of these diagrams and their relative values may give a clearer picture of the copper industry of the United States. In an age when many mineral supplies are being depleted, the conservationist looks carefully at all mineral resources, including copper.

Unlike many minerals, copper has a rather high junk or scrap-recovery rate. Metal so recovered is classified as "secondary copper," in contrast to the new metal from ores, which is classified as "primary copper."

In many cases secondary copper is preferred since it actually represents a high copper content material to work with compared to copper ore, although more care must be taken in refining to break down any alloys that may be present.

The importance of secondary copper in the United States is indicated by Figure 2. Ordinarily, the amount of secondary copper produced is about one-half that of primary copper. In times of poor primary copper production, there are correspondingly poor years of secondary production (Figs. 2 and 3). Likewise, in good years when the demand for copper is high, both production and prices rise. During these times the salvaging of secondary copper is economically advantageous and recovery increases. The recent trend toward the use of secondary copper is the result of war demands, but figures for earlier years reveal that there has been a wide variation in the amount of secondary copper used. The graph does illustrate clearly that the amount of secondary copper available is large when the demand is present. In any analysis of the status of the United States copper industry, it would be wise to recognize that there is a large but undetermined amount of secondary copper in reserve. An estimate would perhaps place secondary copper reserves available 30 years from now at about 200,000 million pounds.

Primary copper production in the United States is illustrated by Figure 3. The highest production was in 1943, and the largest monthly production was in March

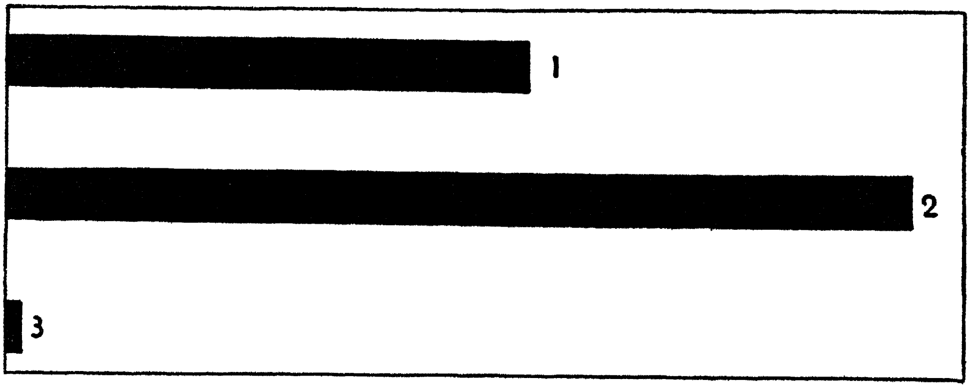


FIG. 5. COPPER PRODUCTION AND RESERVES OF THE WORLD

IN MILLIONS OF POUNDS: 1. PRODUCTION, 1801–1940, 126,775; 2. RESERVES, 219,109; 3. PRODUCTION, 1938, 4,367. DATA OBTAINED FROM *The Minerals Yearbook* AND NEWTON AND WILSON.

1943, when over 200 million pounds came from the smelters. Production decreased after that date as a result of—

1. Decreased labor supply caused by the drafting of men.
2. Increased use of secondary copper representing high ore value.
3. Stock-pile accumulations of the past three years.
4. Diversion of Chilean copper to the United States rather than to European markets.

The copper production of the United States is subject to wide fluctuations, depending upon world economic conditions. In poor years only about one-tenth of the normal supply of primary copper is produced.

These two types of copper (primary and secondary) indicate how much and to what extent copper is being produced in this country for domestic and export use. If one is to make a satisfactory analysis of the status and probable endurance, these two items must be evaluated in relation to reserves. Figure 4 indicates the production of smelter copper in the United States. Item 1 of the figure indicates total production of primary copper from 1845 to 1943 and represents about one-fifth more than the estimated reserves in the United States based on grade ores now being used. Item 3 indicates the production in 1945. At the present rate of production, the reserves would last about 30 years if secondary copper were not used and normal trade were carried on. At the rate copper was produced in 1933, the reserves would last 120 years. The table reveals clearly that our estimated reserves are less than our production so far. With estimated uses of secondary copper and our present rate of consumption, our copper supply could last about 160 years at 1943 production rates.

Figure 5 indicates similar statistics for the world. The remarkable feature of this graph in comparison with the preceding one is that the world reserves are much greater than production. This, of course, is due to the greater usage of metals in the highly mechanized and industrialized United States and to the fact that the United States exports about 20 percent of her annual copper production.

SCIENTISTS AND SOCIAL RESPONSIBILITY*

By P. W. BRIDGMAN

Dr. Bridgman (Ph.D., Harvard, 1908) has been Hollis Professor of Mathematics and Natural Philosophy at Harvard since 1926 and has been in the Physics Department there for nearly four decades. He is well known for his experimental investigation of various physical effects of high pressures. In 1946 he received the Nobel Prize for physics.

THE topic proposed for this symposium, "How far can scientific method determine the ends for which scientific discoveries are used?" is obviously of much generality and also, I am told, of an intentional vagueness. The general background of the topic is plain enough; the topic has evidently been suggested by the present atmosphere through which society is looking at science, inspired by the preponderating role of invention and the applications of scientific discoveries in the late war, culminating in the atomic bomb. Not only is the general public becoming increasingly conscious of the impact of science on the whole social structure, but the scientist has himself in the interval since Hiroshima displayed a noteworthy concern with the social effects of his discoveries. This has resulted in the formation of societies of scientists dedicated to controlling as far as possible some of the aspects of scientific discoveries. There is growing up among scientists a more or less articulate philosophy of what the relation should be between science and society as a whole. It seems to me that it is a matter of the greatest importance what this philosophy is, and that it may well be determinative of the future course of civilization.

There are, I think, unfortunate features in the present trend of this philosophy, and I should like to devote part of this discussion to them. This will involve giving a rather broad and liberal interpretation to our topic. I would in any event be constrained to place a liberal interpretation on it, because it is my feeling that the "scientific method," in the narrow sense in which scientific method is often understood, does not have a very immediate application to determining the ends for which scientific discoveries are used. I like to say that there is no scientific method as such, but rather only the free and utmost use of intelligence. In certain fields of application, such as the so-called natural sciences, the free and utmost use of intelligence particularizes itself into what is popularly called the scientific method. From this point of view I should like to rephrase the topic for discussion to read "What is the most intelligent way of dealing with the uses of scientific discoveries?" A discussion from this broad point of view will necessarily involve aspects of social philosophy, and in particular the philosophy of the relation of science to society.

The detailed discussion might well start with such questions as: How far is it desirable that scientific discoveries be controlled? or, What "ought" to be the attitude of the scientist toward his own discoveries? No discussion along these lines will get very far before the word "responsibility" occurs. Let us examine the implications of this word. It is frequently stated that science is responsible for the uses made of scientific

* This article and the one following are based on papers presented at a symposium on "How Far Can Scientific Method Determine the Ends for Which Scientific Discoveries are Used?" at the annual meeting of the A.A.A.S., Boston, December 1946, in a joint session of Sections K and L and the American Philosophical Association.

discoveries. This is obviously a highly abstract statement. The meaning must be that *scientists* are responsible for the uses made of scientific discoveries. But even this is so general as to have little meaning. Does it mean that scientists as a group are responsible? But what is responsibility that it can pertain to a group? Here we begin to encounter shades of meaning and ambiguities in the word responsibility itself. A few people apparently use the word in a purely factual sense with no further connotations. From this point of view it can certainly be said that scientists are "responsible" for the uses made of scientific discoveries, for the simple reason that the discoveries cannot be used until after the discoveries are made, and the discoveries are undeniably made by scientists. Responsibility in this sense merely denotes a link in the causal chain. But I believe that this colorless and factual use of the word is comparatively rare. The more conventional usage implies a moral obligation and involves a moral condemnation if the obligation is not met. To say that "scientists are responsible for the uses made of scientific discoveries" implies, according to what I believe is the usual usage, that each and every scientist has a moral obligation to see to it that the uses society makes of scientific discoveries are beneficent. This is getting pretty near home. It means that *I* have a moral obligation, and that if I do not meet the obligation I shall be deemed culpable by society and may justifiably be disciplined. The discipline that would be imposed is the natural and obvious one, namely, loss of scientific freedom. This is, I think, the temper of an important part of society today, and the attitude seems to be growing. Furthermore, it is an attitude in which a number of scientists, particularly those of the younger generation, are showing a tendency to concur. Any such concurrence arises, I believe, from a failure to realize the larger implications and involves an essentially short-range philosophy of the relation of the individual to society.

I think it is obvious that the thesis that the scientist is responsible for the uses made of his discoveries must involve the assumption that there is something special and exceptional in the situation. For certainly in more common situations individual responsibility is not considered to extend to all the consequences that may be initiated by the act of the individual. The miner of iron ore is not expected to see to it that none of the scrap iron which may eventually result from his labors is sold to the Japanese to be used against his country. Such an extension of responsibility would be absurd because of the impracticality of it, and in particular would make impossible that specialization and division of labor that is one of the foundation stones of our modern industrial civilization. Furthermore, it is obvious that if such detailed and individual responsibility were imposed a certain ideal of society implicit in the thinking of many of us would have to be abandoned. The society of this idealized vision is a society so constructed that every individual in it may be allowed to strive to choose for his lifework what he can do best. Unfortunately, society is still tragically far from this ideal for the average man, but our departure from the ideal arises, not from failure of good intentions, but from the practical difficulty that we have not yet found a mechanism that makes this possible. However, many individual scientists, so far as they have been allowed to follow the driving force of their inner scientific compulsion, have come pretty close to this ideal. From the point of view of society, the justification for the favored position of the scientist is that the scientist cannot make his contribution unless he is free, and that the value of his contribution is worth the price society pays for it. The demand that the individual scientist be responsible for the uses made by society of his discoveries would constitute

a repudiation of this ideal. For if I personally had to see to it that only beneficent uses were made of my discoveries, I should have to spend my life oscillating between some kind of a forecasting bureau, to find what might be the uses made of my discoveries, and lobbying in Washington to procure the passage of special legislation to control the uses. In neither of these activities do I have any competence, so that my life would be embittered and my scientific productivity cease.

The thesis of the responsibility of the individual scientist therefore involves a repudiation of the general ideals of the specialization and division of labor, and the ideal of, as far as possible, each man to his best. This repudiation can be justified only by some special feature, and the only justification that I can see which is to be taken with any seriousness is the thesis that scientists are in some special way qualified to foresee the uses society will make of their discoveries, and to direct and control these uses. This thesis does indeed seem to be tacit in much of the popular discussion. The question now is whether this thesis is true, and, if so, whether it constitutes justification for the imposition of responsibility. As a physicist with pride in my profession, I would naturally be loath to admit that a physicist could not do a better job than outsiders in controlling the uses made of discoveries in physics, but nevertheless I think an inspection of such activities of physicists as their attempts during the last year to get through Congress a bill establishing the National Science Foundation would show that the batting average of even the physicist would presumably be so low as to make it unprofitable for society to support him in the role of prophet and administrator. For of course society must recognize that if it imposes responsibility on a man it must be prepared to support him in the exercise of that responsibility.

LEAVING further elaboration of this question to the tender mercies of others, I now address myself to the question of whether, even granted that scientists are specially qualified to foresee, direct, and control the uses made of their discoveries, society should therefore hold them responsible for the uses made of their discoveries? I think that the temper of the times is such that many people would answer this question with an unqualified yes. Such an answer implies a social philosophy that has been growing rapidly in this country, namely, that the community has a right to exact disproportionate service from special ability. It is epitomized in the Marxian epigram "From each according to his ability, to each according to his need." Three stages of evolution can be recognized in the present philosophy of the relation of the individual to society. The first granted the right of the bright people to exploit the stupid ones; the second recognized the right of everyone to receive from society a reward proportional to his contribution to society; and the third and present stage recognizes the right of the stupid people to exploit the bright ones. It is perhaps obvious that my sympathies are with the second, or the median, of these three philosophies. The third philosophy, insofar as it involves anything beyond the more or less disguised willingness of the majority to use naked force, is based on a metaphysical concept of society as some superthing, transcending the individuals who compose it. This, to my way of thinking, does not make sense. Society is composed of you and me; society does not have an individuality of its own, but is the aggregate of what concerns you and me. The function of society is expressible in terms of its relations to the individuals who compose it, and any justification for the acts made by its members is to be found only in the effects of these acts on the members of society as individuals.

It seems to me that the thesis of the right of society to exact disproportionate service from special ability can be analyzed very simply. If society exacts disproportionate service, this means that certain individuals in society, acting in their collective capacity, are willing to exact disproportionate service from other individuals. But I, as an individual, would certainly not presume to think of demanding that my neighbor give me special service merely because nature had endowed him to do the job better than I could do it myself. The sort of thing I am unwilling to do in my individual capacity I am also unwilling to do in my capacity as a member of a group. Furthermore, it seems to me only decent and self-respecting for me to do my best to see to it that the group to which I belong does not act in a way in which I as an individual would not be willing to act. If every member of society applied to his social acts the same criteria of decency and self-respect that he applies to his individual acts, the problem of the exaction by society of disproportionate service from special ability would not arise.

The assumption of the right of society to impose a responsibility on the scientist which he does not desire obviously involves acceptance of the third philosophy, that is, the right of the stupid to exploit the bright. There are, I believe, specific objections to the application of this philosophy in the present situation, apart from the general considerations just mentioned. It is not necessary. Society can deal with the issues raised by scientific discoveries by other methods than by forcing the scientist to do something uncongenial, something for which he is often not fitted. The course of action that can accomplish this seems to me the only self-respecting one. The applications made of scientific discoveries are very seldom made by the scientists themselves, but are usually made by the industrialists. It is the manufacture and sale of the invention that should be controlled rather than the act of inventing. This could surely be accomplished by specific action rather than by throwing out baby and bath together. One can think of revisions in the patent laws, for instance, that would be pertinent. Or society can control the situation by other means already in its possession. If it had not wanted to construct an atomic bomb, it need not have signed the check for the two billion dollars which alone made it possible. Without this essential contribution from society the atomic bomb would have remained an interesting blueprint in the laboratory.

Why is it that there is such popular clamor for dealing with this situation by the tremendously clumsy and backhanded method of imposing responsibility on the individual scientist, a method which involves the sacrifice of fundamental principles and the development of social mechanisms of more than doubtful practicality? I suspect the clamor arises from the unconscious operation of very human motives. The cry of responsibility is often no more than the cry of a lazy man to get someone else to do for him what he ought to do for himself. There may perhaps be a small element of despair in the clamor. It is obvious that if society would only abolish war, 99 percent of the need for the control of scientific discoveries would vanish. Furthermore, it is obvious enough that the abolition of war is the business of everyone. The difficulties of doing this, however, appear to have become so enormous that the average man may well despair of being able to accomplish it himself. Into this situation comes the vision that if only some *deus ex machina* would stop scientific discoveries from being put to bad uses we could all be at peace in our minds. Whereupon the human race, with its capacity for wishful thinking and rationalization, needs only this hint to invent the legend of the responsibility of the scientists for the uses

society makes of their discoveries. Let society deal with this situation by the means already in its hands, means by which it deals with similar situations. If it truly believes that the peculiar qualifications necessary to deal with the misuse of scientific discovery are to be found among the scientists, which I, for one, very much doubt, then let it create mechanisms and make opportunities by which those scientists who can do this sort of work well will be attracted to this field, rather than to insist on its right to the indiscriminate concern of all scientists with this problem. And let the scientists, for their part, take a long-range point of view and not accept the careless imposition of responsibility, an acceptance which to my mind smacks too much of appeasement and lack of self-respect.

I believe it to be of particular importance that the scientist have an articulate and adequate social philosophy, even more important than that the average man should have such a philosophy. For there are certain aspects of the relation between science and society that the scientist can appreciate better than anyone else, and if he does not insist on their significance no one else will, with the result that the relation of science to society will become warped, to the detriment of everyone.

The social philosophy which seems to be spontaneously growing up among some of our scientists is, I believe, a short-range and inadequate philosophy. It is well known that the scientists who have shown the most articulate concern with the social implications of the atomic bomb are young. The philosophy that is coming into being betrays this. It is a youthful philosophy, enthusiastic, idealistic, and colored by eagerness for self-sacrifice. It glories in accepting the responsibility of science to society and refuses to countenance any concern of the scientist with his own interests, even if it can be demonstrated that these interests are also the interests of everyone. Such a philosophy is unmindful of long-range considerations and blind to the existence of other scales of values than those of the philosophers themselves.

What are the characteristics of an adequate social philosophy? It seems to me that first and foremost this should be a "maximum-minimum" philosophy. That is, society should be so constructed as to allow the maximum number of its members to lead a good life, while at the same time the minimum of dictation and interference should be imposed on any individual in determining what shall for him constitute a good life. The most outstanding characteristic of such a society is its tolerance. What would be a good life for one man would not be a good life for another. It is, I think, with regard to this minimum requirement that actual societies are most likely to fail. No society dedicated to a special thesis satisfies this requirement. A totalitarian society, such as that of Russia, in which a man may anticipate happiness if he thinks as the majority, but in which he may expect to be liquidated if he opposes it, is obviously not such a society. Neither is the conventional Christian society, with its thesis that the good life is the one devoted to the service of a man's fellows, and with the correlative assumption of the right of the community to impose this ideal on the individual. Both these types of society are too narrow. The broadly tolerant society, committed to no special thesis as to what constitutes the good life, is evidently a late product in the evolutionary chain. When the struggle for survival is too intense, tolerance may well be a luxury society cannot afford. But as the struggle for survival ceases to dominate the social pattern, an increasing amount of tolerance becomes practical, until in the end the attainment of the maximum of tolerance may well become the dominating ideal. This, it seems to me, is the sort of society we should strive for; it also seems to me that in this country

today a high degree of realization of such a society is possible.

WHAT is the relation of the scientist to such a society? It seems to me that he occupies a position of high strategic importance, a position impossible of attainment for the man who has not directly experienced the significant factors basic to this type of society. The conception of what constitutes the good life does not present itself as a primitive datum in consciousness, but is a product of cultivation and education. Furthermore, various ideals of the good life are possible, competitive with one another and to a certain extent mutually exclusive. The ideals that come to prevail will to a large extent depend on the self-conscious activities of those most concerned. It may even be that the ideals will have to be fought for. What constitutes the good life for the scientist does not at once appeal to the majority as constituting the good life. Nay, more than this, without education the majority cannot be trusted to see that it is to the advantage of the community as a whole that the scientist be allowed to lead his good life. With education, however, I believe that this can be accomplished, and that the scientist is strategically situated to impart this education. It is, of course, easy for anyone to see that the material benefits we now enjoy would not have been possible without scientific activity and to see that for this reason science should be supported. What I have in mind, however, is something less material. I think the scientist, in endeavoring to impart the vision of what this is, would do well not to take a too narrow view. The scientific life, which for him is a good life, is a special kind of a more general life which is also a good life, namely, the life of the intellect.

I think the scientist's most important educative task is to get the average man to feel that the life of the intellect not only is a good life for those who actively lead it, but that it is also good for society as a whole that the intellectual life should be made possible for those capable of it, and that it should be prized and rewarded by the entire community. It is perhaps a gamble that society as a whole can be made to feel this. But I believe it is a gamble to which the scientific man is committed. If the human race is such a sort of creature that it cannot be made to feel that intellectual activity and satisfaction of the craving for understanding are goods in themselves, then we might as well shut up shop here and now, and those of us who are made that way henceforth get the intellectual satisfactions necessary to us as best we can, surreptitiously and in spite of our fellows. Example itself can be educative. Appreciation of the element of high adventure in achieving understanding of the ways of nature should not be difficult to impart. In other fields human beings do this. There must be widespread sympathy with, and understanding of the mountain climber who, when asked why he had to climb mountains, replied, "Because the mountain is there." I believe that most men similarly can be made to feel the challenge of an external world not understood and can be made to see that the scientist has to understand nature "because nature is there." The challenge to the understanding of nature is a challenge to the utmost capacity in us. In accepting the challenge, man can dare to accept no handicaps. That is the reason that scientific freedom is essential and that artificial limitations of tools or subject matter are unthinkable. The average man, I believe, can be made to see that scientific freedom is merely freedom to be intelligent, and that the need for this freedom is born with us, and that we will practice it in the inmost recesses of our thoughts no matter what the external constraints. And I believe also that the average man can be made to see that the imposition of restraints on the freedom to be intelligent betrays fear of the unknown

and of himself, and that he can be made to feel that this fear is an ignoble thing. My gamble is that the human race, once it has caught the vision, will not be willing to yield to fear of the consequences of its own intelligence.

It may appear that we have been straying rather far from our ostensible topic. I think, however, that from the broad point of view we have not. What we have been saying amounts to saying that the most intelligent way of dealing with the problems arising from scientific discoveries is to create an appropriate society. This society will be a society that recognizes that the only rational basis for its functions is to be sought in its relations to the individuals of which it is composed; a society in which the individual in his capacity as a member of society will have the integrity not to stoop to actions he would not permit himself as an individual; a society broadly tolerant and one which recognizes intellectual achievement as one of the chief glories of man; a society imaginative enough to see the high adventure in winning an understanding of the natural world about us, and a society which esteems the fear of its own intellect an ignoble thing. In a society so constituted I venture to think the problems created by scientific discoveries will pretty much solve themselves.

INTEGRAL

Each dies a separate death; the blood congeals,
Muscles grow rigid, ice invades the bone;
The heart grinds to a stop, like dragging wheels,
A light goes out . . . and man is left alone.
There is no comfort here; no word can breach
The widening and fathomless abyss
A breath away, yet out of mortal reach—
And there is no aloneness like to this.

Each dies a separate death, alone, apart,
Yet by his very dying he becomes
An integral of one vast, cosmic heart,
One with the dead through all millenniums;
Death isolates, but to unite at last,
With granite link, the present to the past.

Mae Winkler Goodman

THE ROLE OF SCIENCE IN GOVERNMENT

By Felix S. Cohen

Dr. Cohen (Ph.D., Harvard) is Associate Solicitor and Chairman of the Board of Appeals of the Department of the Interior. He is the author of various legal and philosophical articles and books, including Ethical Systems and Legal Ideals *and* Handbook of Federal Indian Law. *He has taught at the New School for Social Research and at Yale.*

IN SCIENCE no less than in government, I think, it is a part of wisdom to recognize that not every sentence followed by a question mark asks a question.[1] The text for discussion, "How far can scientific method determine the ends for which scientific discoveries are made?" ends with a question mark. But in order for this to pose a significant question two preconditions would have to be met: first, it must be possible for a method to determine an end; and, second, this process of determination must be measurable, so that some constant can be substituted for the variable "how far?" For my part I cannot, for the life of me, understand how any method can ever determine an end. And I therefore see no point in trying to decide whether such a process of determination, if it existed, could be measured. I shall, therefore, not attempt to give an answer to what I think is not a question. Let me instead take this opportunity to treat our text not as a question to be answered, but as a symbolic indication of interest, and perhaps of confusion, that deserves to be explored.

What we are interested in, I suppose, is the question of whether and how human beings can be scientific in marking out social goals, standards, and controls to govern scientific research and technology. The process of influencing, criticizing, and controlling scientific activity is carried on by college trustees, corporate boards of directors, governments, and many other agencies. Because my own knowledge of the mores of college trustees and corporate directors is rather limited, I propose to restrict my comments to the problem of governmental or political influence or control over the activities that comprise science. Specifically, I propose to address myself to the problem of whether we can be scientific in the political control of scientific activities.

Let me at the outset try to dispose of a common language block to clear thinking on this problem. It is frequently said, and even more frequently assumed, that political control of science or technology is either impossible or wholly calamitous. "Political medicine" is the bad name that some physicians like to give to programs of government-subsidized medical service, to save the trouble of arguing the merits or demerits of such programs. Such are the dyslogistic overtones of the adjective "political" that further argument appears superfluous. And perhaps the word "control" has similar overtones. Let us, however, following the advice of Justice Holmes, wash our words in cynical acid and recognize that political factors, in the sense of factors of policy or government, are inevitably involved in the control of technology, and that control is positive as well as negative, including assistance as well as restriction.

Let us, in the same spirit of operational realism, which Professor Bridgman has so ably advocated in the physical realm, recognize that "disciplining" scientists may be only a dyslogistic way of referring to the award of Nobel Prizes, and that the

"right of the stupid to exploit the bright" may mean no more than the duty a great physicist is under to expound his ideas to fellow mortals of lesser intellect. At any rate, the problems remain when emotion evaporates. Research facilities may be taxed or untaxed, publicly subsidized or not, permitted to accept private donations and bequests or not. Free public education may stop at the high-school level or run through college or postgraduate courses. Government agencies may restrict or expand their present research activities in the natural or the social sciences or in both. Which of these possible courses should be followed? And how should the products of government research be distributed to the public? Should inventions that result from government research belong to the public or to the individual government employee who completes the invention? How far should the government go into the atomic-energy business, or into the power business generally? How much freedom should public servants enjoy in publicizing their findings and theories, and who should fix and judge the limits of such freedom? These questions, which seriously affect the future of science in this country, are inevitably political, and we do not guarantee the correctness of our answers by refusing to face such question openly or by failing to appreciate the conflicting considerations that may lead reasonable people to entertain divergent views in answering them.

To say that it is possible, and even desirable, to weigh such political alternatives and questions as these is only to touch the edge of the problem before us. What is more important to recognize, perhaps, is that social control or direction of technology is not only one among many functions of political organization, but, over the span of recorded history, probably the most important single function of political organization.

If we look for instance, to the Stone Age culture of our own Plains Indian society, where the buffalo hunt was the principal source of food, clothing, and shelter, we find that the social control of buffalo hunting was the major axis of political development. The buffalo police came into being in the buffalo-hunting season, when whole tribes and nations united, in order to make certain that no unsocial or unskillful individual hunted in such a way as to frighten away the herds. At other times of the year Plains society was highly individualistic, and single families, bands, or individuals might hunt deer or bear as they pleased, without police supervision. But when the existence of a whole people was at stake and depended upon a minutely elaborated technology for sustenance and survival, a police force was called into being.

So, too, if we look at the irrigation-farming society of the Pueblo Indians, we find a society dependent upon a carefully developed technique of irrigation, and control of the irrigation ditches and the use of irrigation water are to this day the focus of Pueblo government and the ultimate sanction of communal discipline. If we look at the old Southern plantation economy, we find techniques of operation and management that are reflected and supported in the present government machinery of the plantation states. In a society of traders or raiders, government focuses on the canons and techniques of trading or raiding.

At every level of civilization, we find that acts which disturb or seem to threaten the accepted way of making a living are the most serious of crimes. On our old Western frontier men might forgive many departures from the moral codes of the East, but there was no argument about horse-stealing, which cut the thread on which travel, communication, and livelihood hung in the technology of the frontier.

The precarious dependence of all human

living and civilization upon the maintenance of man's technological control over nature is ever-present today. Though the threat of starvation, which has haunted mankind for a million years and still haunts most of the world, no longer looms before our eyes in this blessed land, the atomic bomb has made us all realize that our lives and our children's lives hang in the balance while we seek to fashion effective controls for our technology.

Today we are beginning to realize the inadequacy of the old-fashioned materialism that viewed human development as a product of geography and natural resources, with technology appearing as a by-product of resources. Today we are beginning to appreciate that what is a natural resource is itself a function of our technology or resourcefulness.[2] Human intelligence can make airplane wings out of sea water, fertilizers out of air, little atoms out of big atoms. Set a scientist down in a desert or a wilderness and he will begin to discover resources, wealth, opportunities. Take science from a prospering land and it will relapse into desert or wilderness. If, as a distinguished economist has well said, the fundamental category of economic activity is power,[3] then, as surely as knowledge is power, knowledge is the basis of every economy.

Today a modern scientist may paraphrase Archimedes to say: "Give me control over a nation's scientific development, and a long enough span of years, and I will raise or lower its level of income or power to any assigned point." Compare the strength and the standard of living of a country like Switzerland, incomparably poor in natural resources but rich in vision and skill, with that of Rumania, abounding in natural resources but lacking in science,[4] and you will find a key to many traditional mysteries of international intercourse and of our own national development.

If, then, the control or direction of technology is inevitably a political question and perhaps, as I think, the most central and most important of all political questions, the question that faces us is: What light can science throw on the proper direction of such control?

Perhaps the most persuasive answer to a question of this sort is one given by historic fact. The scientists of this country have undertaken within the past two years to help direct the course of atomic-energy development in this country by cooperating with politicians or, if you prefer, statesmen—if it is ever permissible to apply the term to politicians who are not yet dead. Our physicists and other scientists lectured for some months to a senatorial seminar arranged by Senator McMahon and found a willing audience. As one who played a very minor role in the preparation of testimony and the drafting of legislation in this field, I should like to pay my tribute to the public service rendered by our atomic scientists in awakening and informing public opinion. It was the scientists, speaking with the authority that a preface of thunderclaps assures, who called attention to the dangers inherent in certain legislative proposals in the field of atomic energy. Those proposals might now be law but for objections that scientists then voiced. Those proposals, we soon realized, threatened the basic principle of our American democracy, the thing that distinguishes us from so many sister-republics of this hemisphere, civilian supremacy in government. I think we have taken the first brave steps toward making atomic energy a source of peace and plenty rather than an endless catastrophe. I think we have achieved a reasonable compromise between the need for freedom of research, which is an essential part of free thought, and the need for public control of its military and economic applications.[5] If we have achieved this result, it is because our scien-

tists and our politicians were able to realize that they live in One World. If we have not completely attained the Platonic ideal that will come into being when kings become philosophers or philosophers become kings, we have, I think, made a modest stride in that direction in dealing with atomic energy.

Such a result was possible in the field of national legislation, for one thing, because our Congress, not being limited, as many state legislatures are limited, to meeting for a few weeks every other year, is able to give patient attention to scientific evidence on important political issues, whenever they arise, and to act in the light of the evidence. How Congress has been able to survive the popular Calvinistic theory of the depravity of government which has led to the extraordinary restrictions fastened upon the meetings and activities of nearly all our state legislatures, I do not know. But I think it fortunate for the country that we do have a national legislature that is ready, able, and willing to have the light of science thrown on current problems at any time. Members of Congress are not always scholars, but I see no reason why American scientists should ever hold up their hands in horror at the prospect of educating Congressmen or their constituents on matters that profoundly affect our lives. After all, Socrates was able to demonstrate geometric proofs to a slave boy.

NOT only in the field of atomic energy, but in many other fields as well, do we find scientists testifying patiently and effectively before committees of Congress, as to the probable consequences of one legislative course or another. Proposed legislation for the establishment of a National Science Foundation,[6] for the expansion of public health services, and for the interchange of teachers, students, and research workers with other countries evoked effective testimony from distinguished American scientists. And year after year government scientists go before appropriation committees to justify appropriations for government-financed research. Just think what it means to justify an appropriation for research. It means finding a common measure for the impact of taxation on human lives and the probable outcome of a search into the unknown. And it means a choice among competing proposals for disbursing national funds in a field which includes not only many different lines of physical and social research but also works of national defense, subsidies to agriculture, and law enforcement. And despite all the fashionable doubts as to the commensurability of human values, these goods have to be weighed against one another, for each public dollar can be spent only once. If the justification of basic research under those conditions seems a dreary and impossible task to those who have never sat across a table from an appropriations committee, let me quote the reassuring comment of a scientist in the Department of Agriculture:

> I have been going up before appropriation committees for this Department for close to forty years and I never have found a committee that as a whole wasn't favorable to fundamental research, whether we could show any immediate returns or not. In all of my experience, any sound piece of research has always had their support, and I have known them to make appropriations for such types of research even against the recommendation of the Bureau of Budget and the President.[7]

The receptivity of our Congress to impartial scientific evidence on issues of national significance is paralleled, I believe, by the attitudes of most of our executive or administrative agencies. Organizations like the Bureau of Standards, the Bureau of Labor Statistics, the Bureau of Mines, the Geological Survey, the Public Health Service, and the many research agencies of the Department of Agriculture seek not only to trace

the latest technological developments in their respective fields, but also, so far as possible, to measure the human consequences of such developments and to bring this knowledge to bear upon the administration of governmental bureaus. Many of us are discouraged, from time to time, because in one matter or another some administrative body has paid too much attention to an outworn and disproved theory and not enough attention to the latest scientific findings. But do we not often make the same observations about our students and even our academic colleagues? And if we try to take a long-range view of things and compare the amount of up-to-date scientific data that is available to present-day government administration and used in the process of administration, with what was available, say, in the days of Bentham, we can get some conception of just how far we have progressed along the path that Bentham charted, the path of molding law and administration in the light of the human welfare and human suffering that follow therefrom.

As a lawyer I am sorry to have to report that there is at least one field in which the scientific search for truth has hard sledding, and that is before the judicial branch of government. The spirit of the contest by hired champions still dominates litigation, and for the court to go beyond the presentation by interested parties and to embark upon impartial scientific investigation of its own, perhaps with the aid of recognized scientific bodies and authorities, would appear to many judges and lawyers to be an unforgivable departure from the sporting spirit that should control litigation. Yet I wonder whether we have not outgrown the right to rely on hired champions, whether they wield medieval battle-axes or modern theories of psychoanalysis or economics, in our search for the truth in courts of law.

Differences of opinion in our Supreme Court, for instance, as to the consitutionality or even the interpretation of statutes generally turn upon differences of viewpoint as to the "reasonableness" of various statutory requirements, and these differences, while they may turn on ultimate ethical disagreements, seem generally to be based upon divergent views as to the actual consequences of the act or the interpretation in question. Yet there is no recognized way in which the Supreme Court may call upon any scientific body for impartial advice on the facts. The result is that the Supreme Court's pronouncements and assumptions on matters of economics, anthropology, biology, and technology are often made in disregard of the sources of scientific information that are available to Congressional committees. Thus, for example, in the case of *Alcea Band of Tillamooks* v. *United States*, decided November 25, 1946, four justices of the Supreme Court thought that failure to pay Indians for surrendered lands was a departure from accepted mores of government activity, justifying an award of compensation, while three justices dissented from the allowance of compensation on the ground that taking lands from Indians without compensation was the usual and commonly accepted way of doing business a century ago. On this issue of political and economic history neither party to the case presented any evidence at the trial, and the Supreme Court had no way of calling for expert and objective testimony on an issue of historic fact.

The need for access to impartial sources of scientific knowledge is even greater, though perhaps not so dramatic, in the lower courts. Why should a trial judge have to choose between two hired experts testifying for one side or the other on questions of psychiatry, medicine, chemistry, economics, or anthropology? Would it not be helpful in the search for truth if courts could call for testimony from panels of disinterested

scientists nominated by appropriate scientific bodies and paid, not by one party or the other, but out of the same public funds that are available for judicial salaries and other expenses of the administration of justice?

I hope that someday the American Association for the Advancement of Science or some of its constituent organizations will give thought to ways and means of making scientific knowledge available to our courts of justice in an objective and impartial way that will command respect both for our science and for our law. I do not think such a project is by any means fanciful. Our wisest judges have long recognized the dependence of justice upon science.

> I have had in mind [to quote Justice Holmes] an ultimate dependence upon science because it is finally for science to determine, so far as it can, the relative worth of our different social ends, and, as I have tried to hint, it is our estimate of the proportion between these, now often blind and unconscious, that leads us to insist upon and to enlarge the sphere of one principle and to allow another gradually to dwindle into atrophy. Very likely it may be that with all the help that statistics and every modern appliance can bring us there never will be a commonwealth in which science is everywhere supreme. But it is an ideal, and without ideals what is life worth? They furnish us our perspectives and open glimpses of the infinite (O. W. Holmes, Law in Science and Science in Law, *Collected Legal Papers*, 210, 242).

There are today many practical approaches toward such a liaison between science and justice. In many juvenile courts we have trained psychiatrists, criminologists, and physicians attached to the court itself and able to furnish unbiased information to the judge. In some civil cases, where intricate questions of geology, psychiatry, economics, or industrial technology are involved, special masters with scientific training are appointed by the courts to get at the facts. Only a year or so ago new rules of criminal procedures were promulgated for the Federal courts and this code, for the first time in our history (thanks, I believe, to the efforts of my distinguished colleague Professor George Dession), authorizes the Federal courts to appoint expert witnesses on its own motion.[8] We ought, I think, to have some similar procedure in civil cases, and particularly in constitutional cases. And, above all, when the judiciary takes this step toward an effective liaison between science and justice, there ought to be some reciprocal step taken on the part of scientists to see that this affair is a durable marriage and not merely a liaison.

This, of course, is only a small part of the area in which science may function to make government more scientific. As an old bureaucrat who has served for more than thirteen years in the Office of the Secretary of the Interior, I may say that I can think of no more important step toward good government than action by American scientists, through their professional organizations, to subject the scientific assumptions that underlie our laws and their administration to systematic scientific scrutiny. Take, for example, our racial laws, laws which seek to control man's biological development in this country by gerrymandered immigration quotas and the various restrictions on citizenship and land ownership that rest on racial grounds. Is there not some responsibility on the part of biologists and anthropologists and other professional scientists to expose the pseudo science and the disproved hypotheses on which so much of this legislation rests? Of course there may be some who will uphold these laws, whatever the facts may be, and I am not suggesting that tracing the consequences or the assumptions of a given course of political action will ever be enough to defeat or establish such action as a matter of logic. Always there remains a question of ultimate values. I shall recur to this in a moment. For the present I am contending only that the process of government always involves assumptions and hypothe-

ses as to positive fact and that scientists can help to see that these assumptions and hypotheses are considered in the light of the available scientific evidence. In this process we may come to realize that every law and every ruling involves implicit predictions and deserves to be reconsidered whenever these predictions are not borne out by the facts. That, I take it, is one essential of the scientific approach to government and law. To the extent that this approach is implemented in reality, government can become more scientific than it is. Conversely, to the extent that we may have a reaction against "experimenting," "guinea pigs," "questionnaires," "theories," and "professors," government may become a good deal less scientific than it now is.

The upshot of our argument thus far is that the activities of scientists are just as proper a subject of social control as the activities of businessmen, irrigation-water users, patent owners, or horse thieves, that this social control of scientific research and its applications is largely exercised through the usual agencies of government, and that existing governmental agencies in this field are more or less receptive to the influence of scientific data impartially presented, and might be more receptive if scientists put forth a more sustained effort to make their data available to the agencies of government. All this, however, focuses on the role of factual knowledge in enlightening the process of government. Is that all there is to the fixing of social goals?

SUCH words as "ethics," "morals," and "the good life" have acquired, during recent decades, the musty odor of Sunday-school rooms that are open only once a week. Under the influence of nonscientific conceptions of ethics, and particularly under the view that conscience can give an infallible answer to any ethical question, ethics during the nineteenth century was forced to abandon the empire it once claimed over the world of science, industry, law, and civilization. So attenuated in its dominion, ethics could command respect only by issuing the one command with which every weak sovereign may secure obedience, the unbreakable command: "Do as you please." The morality of *laissez faire*, applied to economics, law, education, art, and science, reflects the bankruptcy of a society in which no group recognizes its obligations to the rest of humanity. Such a fissionable society cannot, I think, long endure. Certainly it cannot long endure alongside other societies where the objectives of all groups are systematized and reasonably coherent.

The search for a systematized and coherent pattern of values is not a new thing in the history of our civilization. In the works of Aristotle and Plato, in the Pentateuch, and in the great synthesis that Scholastic philosophy made of the Hellenic and the Semitic traditions, there is clear recognition of the fact that all human conduct is subject to moral judgment because we all live in One World where all human conduct affects human weal and woe. In the light of this recognition neither science nor art nor education nor law can be removed from the realm in which significant moral judgments may be passed. Conversely, modern ethics cannot ignore the data of science in favor of the promptings of conscience, which is itself, in large part, like common sense generally, a compote of old scientific and philosophical theories that has been stewing for a few hundred or a few thousand years. Modern ethics recognizes that insofar as we pass moral judgment on acts without knowledge of their consequences we literally do not know what we are talking about.

The physical scientist can claim credit for the conquest of energy that has made civilization compatible with human equality by making it possible to substitute mechanical slaves for human slaves. By the same token,

he cannot escape, any more than any other member of society, responsibility for the human suffering he helps bring to pass. And only an informed appreciation of the way in which science operates to relieve human suffering and banish ancient fears and ancient pains can assure to science the social support that it deserves. I think that our society of today is on the brink of rediscovering these ancient truths, and that the famous slogan of a successful American businessman, "The public be damned," is going to find fewer adherents in the coming generation than it has found in the past, not only in the ranks of businessmen, but also in the ranks of poets, painters, lawyers, and scientists. For the arts and sciences, as for the nations, isolationism is obsolete.

Let me hasten to add that I think the pursuit of truth through science is assuredly a good in itself that needs no ulterior justification, any more than love or art or chess or law, conceived as an indoor sport. But when chess is played with human pawns, the pawns as well as the players have a right to be heard. The pursuit of truth, like the pursuit of beauty or happiness or what is called *elegantia juris*, if carried on in a society of many individuals in such a way as to bring destruction or injury to some of them, must appear when called before the bar of some more comprehensive moral judgment. If the scientist lived his entire life in an ivory tower and undertook to destroy the tangible results of his research upon its completion, there might be some ground for the argument that society has no right to interfere or concern itself with scientific research. Perhaps there are some scientists who do live in such towers. A great mathematician once said that the best thing about the theory of prime numbers was that nobody could ever by any chance put it to any practical use. I am not sure that this is still true in these Pythagorean days when our very lives are balanced upon atomic numbers like U-235. But certainly outside the theory of prime numbers there is no field of science that does not have a bearing on human happiness and human suffering, and no field, therefore, from which ethical judgment can be excluded.

Such ethical judgment may be enlightened or unenlightened. It is more likely to be enlightened if scientists themselves, as educators, participate in the process of public enlightenment and participate, as citizens, in the formulation of social policy. And if, as I believe, citizenship carries a duty to contribute knowledge, as well as taxes, in proportion to ability or income—notwithstanding Professor Bridgman's objection on both counts[9]—then the civic duties of the scientist are not negligible.

The question remains: Can ethical judgment be enlightened or is it inevitably a magical or religious but definitely not a scientific affair? Is there an unbridgeable gulf between the world of "is" and the world of "ought," such that the methods of science applicable in the former realm are of no relevance to the latter?

I have elsewhere argued that ethics itself is, at least potentially, a science and that judgments of value can be scientifically analyzed, refined, corrected, and systematized, just as judgments of time, weight, or space can be.[10] For the present it is enough to state the position in agnostic terms. I know of no point at which the scientific search for facts needs to stop short of complete understanding of all the relevant factors in any problem situation.

Most supposed ethical disagreements turn, I believe, upon different estimates as to the actual consequences of alternative forms of conduct. And certainly the tracing of consequences of conduct is a proper domain of science. There is, however, in the last analysis, a point at which one must stop tracing the consequences of any course and judge that in the light of all these conse-

quences the course in question is desirable or undesirable. Does one thereupon move into another world, a world from which science is forever barred?

To distinguish between "is" and "ought" is proper enough, just as it is proper to distinguish between "is" and "is not." The proposition "Hitler is alive" is as different from the proposition "Hitler ought to be alive" as both are different from the proposition "Hitler is not alive." But this does not mean that there is a world of *ought* and a separate world of *is*, any more than it means there is a world of *being* and a separate world of *nonbeing*. The difference between "is" and "is not" is relative; "A is not B" is equivalent to "A is C;" "Hitler is not alive" is no different than "Hitler is dead." So, too, there is, I think, only a relative difference between *is* and *ought*. To say that we ought to avoid an atomic war is, I think, substantially equivalent to saying that we shall, in the long run, avoid a great deal of suffering by averting such a war.

Whether I am right or wrong in considering suffering to be the only intrinsic evil in the world, and well-being or happiness the only intrinsic good, the fact remains that any ethical theory that purports to follow the canons of science must use empirical terms in defining the good life, and I see no reason why any body of empirical observations may not become the material of science if approached in a scientific spirit. I would say that one approaches ethics in a scientific spirit if he has what Professor Bridgman has referred to as the scientist's religious humility before ultimate facts[11] and is ever ready to revise his theory to accommodate the facts.

Now it seems to me that the facts of ethics are as ineluctable as the facts of color. Things appear to us as good or bad, as they appear black or white, large or small, round or square. These observations are not infallible, since, as Kant pointed out, actual observation always involves, in addition to pure perception, a conceptual element which involves judgment. But such observation, whether of color or value or the position of pointers on instruments, offers the only possible material for empirical testing of any theory. Such observations are subject to correction and refinement as we learn how to separate what is actually perceived from the conceptual mass that the observer brings to the relation of observation. But we cannot ever eliminate these observations from the body of any empirical science.

If we eliminated felt time and felt weight and perception of color from physics we should have only a circular and empty mathematical system in which time is the measure of motion and motion the measure of time and neither has any verifiable existence. In the same way ethics becomes an empty logical system if immediate perception of good and evil is eliminated, and yet our observations, in ethics as in physics, are fallible and correctible. Such observations and judgments are perhaps not absolute, but if they are relative to perspectives or coordinate systems we can still hope to find formulas of translation from one system to another or, at the very least, realms of agreement. And although we recognize, with Aristotle, that we cannot expect the same precision in political science as in physics or mathematics, the fact remains that people do agree on some ethical observations about as well as they do on most physical observations. This is shown when, for example, the Senate of the United States passes a bill on atomic energy by unanimous vote. In fact, the essence of politics in a democracy is the search for points at which a multitude of ethical systems with disparate starting points and divergent goals can converge in a common observation. Without such convergences and the political skill to discover them we should have not a society but what Hobbes aptly called a "war of all against

all," on a domestic as well as an international scale.[12]

There was a time when the custodians of the world's science considered the heavenly bodies a proper sphere of scientific interest but looked with disdain upon those who sought to apply similar canons of analysis to such mundane affairs as the rate at which stones fall or pendulums swing or blood flows. Yet the progress of science has always depended upon the happy fact that some scientists have not cringed before these looks of disapproval or bowed before iron curtains and have ever been eager to push the techniques of science to new fields "beyond the utmost bound of human thought." If we are not to put ourselves in the laughing stocks of history alongside the persecutors of Galileo, let us not set limits upon the possibilities of ethical science. Let us not set bounds upon what is truly an endless frontier.

REFERENCES

1. COHEN, FELIX S. What is a Question? *Monist*, 1929, **39**, 350.
2. ———. "Things are not resources in themselves; they become resources as men grow more resourceful. The economic order is itself an order of human wants and sacrifice, satisfactions and acts of will. Technology is a form of knowledge." The Relativity of Philosophical Systems and the Method of Systematic Relativism. *J. Phil.* 1939, **36**, 57, 64. The most incisive analysis of this issue that I know is to be found in COHEN, MORRIS R., *Meaning of Human History*. In press, chap. 5.
3. KNIGHT. Social Science. *Ethics*, **51**, 127, 139; COHEN, M. R. Property and Sovereignty. *Law and the Social Order*, 1933, 41.
4. CLARK, H. F. *Education Steps Up Living Standards*. Washington: U. S. Chamber of Commerce, 1945, 12-13.
5. Cf. Secs. 3-7, 10, Atomic Energy Act of 1946, approved August 1, 1946. *Pub. 585, 79th Cong.*
6. PARSONS, TALCOTT. National Science Legislation. *Bull. Atomic Scientists*, 1946, **2**, (9)7-9.
7. WOODS. Symposium on paper by CARLSON, A. J. How Can Science Get Support in a Democracy? USDA Graduate School. 1939, 235.
8. *Federal Rules of Criminal Procedure*, Rule 28, 1945. See, also, BEUSCHER, J. H. Use of Experts by the Courts. *Harv. Law Rev.*, 1941, **54**, 1105.
9. It is "puerile," Professor Bridgman thinks, to say "that science has a responsibility for seeing that its inventions are not misused." (*The Intelligent Individual and Society*, 249). And neither is it "fair," in his opinion, for society to be picking on men of great wealth by requiring "that an unusually great proportion of that wealth be turned back in the form of taxes (*Ibid.* 291)."
10. *Ethical Systems and Legal Ideals*. 1933.
11. *The Logic of Modern Physics*. 1927, 2-3.
12. SMITH, T. V. Compromise: Its Context and Limits. *Ethics*. 1943, **53**, 1.

Book Reviews

THEY MOVE IN THE VOID

Meet the Atoms. O. R. Frisch. xiv + 226 pp. $3.00. Wyn. New York. 1947.

The Atomic Story. John W. Campbell. vi + 297 pp. Illus. $3.00. Holt. New York. 1947.

Explaining the Atom. Selig Hecht. xiv + 205 pp. $2.75. Viking. New York. 1947.

ATOMIC bombs, atomic power, atomic age, atomic scientists, atomic information, atomic, atomic, atomic . . .

Many books are already in existence and are being published on every angle of atomic energy. But *what is the atom?* The book by Dr. O. R. Frisch fills the gap in the existing literature, and those readers who will go carefully through its 226 pages will know at least what they are talking about when they speak of the atom. It supplies this minimum of basic physical knowledge, which is absolutely necessary for the understanding of the questions concerning the immense amounts of energy hidden in the central nucleus of the tiny atomic body.

The author of *Meet the Atoms,* together with Professor Lise Meitner (who wrote the preface to it), was the first to interpret the epoch-making experiments of Hahn and Strassmann as the *fission* of atomic nucleus. During the war Dr. Frisch was active in the Manhattan District, for he was a recognized authority on atomic energy. He is now working in England on the same class of problem. This fact, which guarantees the authenticity and perfectly scientific angle of the presentation, is probably also responsible for the extreme shortness with which the basic problem of nuclear fission and the large-scale liberation of atomic energy is treated in the book. But for those who are interested in the question of *what* the atom is and not *how* to use atomic energy, Dr. Frisch's book certainly represents a well of knowledge.

G. GAMOW
The George Washington University

THE book by John W. Campbell, *The Atomic Story,* is intended for popular reading and for its greater part is quite successful in its aim. On such a subject as atomic physics, this is no mean achievement; and, if in a few places the author falls below his average standard, this is only what must be expected of a writer on any subject.

The author's treatment of his subject is historical in character. He points out that there have been two lines of discovery in physical science that in recent years have coalesced into one. One of these lines began with the discovery that matter was not continuous but granular in structure; in other words, that there were such things as atoms. Centuries later, it was found that even these atoms were not the ultimate particles of matter, but were composed of still smaller subatomic particles.

Electrical science had a parallel development, beginning with the ancient knowledge of the attractive power of rubbed amber. The author traces the growth of our electrical knowledge from Franklin's time up to the development of the Crookes tube. He then points out that some twenty years later the discovery of radioactive substances brought about the union of these

two lines of development by showing that the subatomic particles were electrically charged.

In the chapters dealing with the subsequent development of these united lines, culminating in the discovery of atomic fission and its application to the atomic bomb, the author is at his best. In some parts, these chapters are not as easy reading as those dealing with the earlier history of the subject and must be read as carefully as the proof of a theorem in geometry; but, considering the advanced nature of the subject, this, too, is only to be expected.

The book closes with a chapter entitled The Human X in Atomic Politics, which contains many good points. It closes as follows:

> There are two great tasks for the next half century: We must learn more about atomic forces. But we'd be wise if, first, we learned more about man—the one greater force that can twist atomic energies to its will.

However, there are in this excellent book a few places where alteration is advisable if opportunity offers in a second edition. On page 18, where the author discusses the attraction and repulsion exhibited by rubbed rods of glass and hard rubber, his treatment leaves something to be desired. For instance, he says in one place: "Since in ordinary uncharged matter there are electrons in numbers just equal to protons, the glass rod will attract bits of ordinary matter because it attracts their electrons." But what about its repulsion for their protons?

The fact is that these phenomena, in the light of our modern knowledge of electronics, are by no means so simply explained as the author does it. He lays emphasis on the friction of silk on glass as breaking off electrons from the surface atoms of the glass, much as a dustcloth wipes off dust and carries it away. The modern view is that the only function of the rubbing is to bring about a close contact between the two substances; then there comes into play the contact electromotive force discovered by Volta, for which we have as yet no perfectly satisfactory explanation.

On page 105 (and several other places) reference is made to the periodic table of elements. The nonscientific reader is not likely to have a copy of this table to refer to; and even the scientific reader might not have for ready reference the special form of the table mentioned by the author, which gives figures for the binding energy for atoms of different sorts. The book should contain a copy of this table.

Mention should also be made of the nonscientific pictorial illustrations. These contribute nothing to the understanding of the subject and can hardly be regarded as ornamental.

PAUL R. HEYL

Washington, D. C.

ALTHOUGH there is not a word of politics or sociology in *Explaining the Atom*, it is, nevertheless, by purpose and design, a book that is profoundly provocative in its political and sociological ramifications. By conveying to laymen the intellectual drama of the developments of atomic physics during the past fifty years, Selig Hecht, Professor of Biophysics at Columbia University and honorary Vice-chairman of the Emergency Committee of Atomic Scientists, has written a book supplying a frame of reference by means of which individuals can think, act, and vote intelligently in dealing with the important issues concerning atomic power. That there is great need for such an undertaking can be readily recognized, for only by understanding the basis and development of atomic energy can one judge the legislation and foreign policy that concern it.

Since the exploding of atomic bombs over Hiroshima, Nagasaki, and Bikini, many ridiculous notions about the origin, the na-

ture, and the secrets of atomic energy have been disseminated. Actually, as Professor Hecht points out, the subject, through the scholarly efforts of scientists all over the world, has had an orderly history and development. Hecht portrays this development in terms of the historic steps that were taken in going from the earliest questions about the nature of substances to the large-scale liberation of atomic energy. Clearly and simply, without assuming any previous knowledge of physics, chemistry, and mathematics on the part of his readers, he weaves a bright fabric of the light and dark threads of atomic analysis—packing factors, fast and slow neutron analyses, combining ratios of substances, Einstein's mass-energy equation, nuclear fission, and the chain reaction.

In addition to being able to grasp these analytical protrayals, the reader is able to make computations in terms of Einstein's mass-energy equation to obtain some indication of the possibilities of a uranium chain reaction in the production of atomic energy. If, for example, all the atoms in a pound of U-235 were fissioned, the energy produced would be over 400 billion billion ergs, or, in common units, 12,000,000 kw-h. Released slowly under control, this energy would furnish the electric current to keep 12 million 100-watt lamps going for a 10-hour day, or about enough to illuminate all the homes in New England for an evening. Released quickly, in a fraction of a second, it would have the explosive force of 10,000 tons of TNT. Pound for pound, U-235 could yield an explosive force 20,000,000 times more powerful than TNT; and, even if only 1 percent of the atoms in a pound of U-235 were to fission, it would still be equivalent to 200,000 times the explosive force of TNT.

It is more than likely that some academicians will censure Professor Hecht for oversimplifying the story of the atom. Nevertheless, his book, despite its lack of scholarly accessories, makes palpable the intricacies of a segment of science that comprises one of the most fascinating chapters in the history of the human race. As such, it is an invaluable contribution to laymen who conscientiously seek to understand nuclear fission, the better to utilize its motive and curative power as a new, worldservant.

James J. Jelinek
School of Mines and Metallurgy
The University of Missouri
Rolla

KNOW THEN THYSELF

The Life of a Chemist. Memoirs of Vladimir N. Ipatieff. Zenia Joukoff Eudin, Helen Dwight Fisher, and H. H. Fisher, Eds. V. Haensel and Mrs. R. H. Lusher, Translators. xv + 658 pp. $6.00. Stanford. Stanford University, Calif. 1946.

SCIENCE is not merely a body of accumulated knowledge, a system of facts and laws, but is in itself a creative force that permeates all human activities and, under the catalytic action of congenial brains and the pressure of historic events, brings forth ever-new knowledge and enlightenment. This dynamic concept of science is illustrated by the life story of the great Russian chemist Vladimir Nikolaevich Ipatieff, who is best known as the discoverer of pressure catalysis, although his scientific achievements are not restricted to this important field of organic chemistry.

In reading Ipatieff's autobiography one notices that it is not only the vividly told story of a long, eventful, and fruitful life and of an extraordinary and distinguished career, but also the history of chemical science during the last century and of the outstanding chemists of the last three generations, with most of whom Ipatieff stood in direct scientific and personal contact.

Ipatieff's early scientific career developed under the dominating influence of the other great Russian chemist, Dmitri Ivanovich

Mendelyeev, whose discovery of the periodic law of atomic weights laid the foundation of modern inorganic chemistry and nucleonics. As Mendelyeev was half a century ahead of the general progress of inorganic chemistry, so was Ipatieff fifty years in advance of organic chemistry by the discovery of the catalytic action of metals and metaloxides. In fact, catalysis, especially when applied under high pressure and at high temperature, was of greater practical importance to world chemistry and industrial development than was Mendelyeev's law, which for a long time remained in the theoretical realm.

In Germany Ipatieff studied under the master of organic synthesis, Adolf von Baeyer, and worked in his laboratory in Munich next to Richard Willstätter, the discoverer of chlorophyll, and Moses Gomberg, who was to become one of America's greatest chemists. In France Ipatieff was in contact with Pierre Berthelot, the founder of thermochemistry, as well as with Sabatier and Senderens, who were working on catalytic hydrogenation. But it was Ipatieff's scientific genius that brought catalytic action and thermodynamic effects together in studying the effects of such catalysts as iron, nickel, zinc, or alumina under pressures up to 200 atmospheres and at temperatures up to 600°C.

These experiments not only started a new chapter in organic and industrial chemistry by making possible the controlled composition and decomposition of organic compounds, but they also elucidated the origin of petroleum in nature and led the way to a better utilization of natural petroleum and to the synthesis of petroleum products from coal. Thus Ipatieff's achievements in the field of pressure catalysis were the foundation stone upon which a second generation of chemists in the industrially more developed countries of the world has built the enormous structure of industrial chemistry. It is this second generation of modern chemists with whom the Russian scientist was in close contact, and his autobiography proves conclusively that the amazing growth of chemical industry in our century is not so much due to the solitary work of individual scientists as to scientific cooperation and exchange of knowledge on an international basis.

It is this international cooperation of scientists in which Ipatieff ardently believes and to which he strenuously but unsuccessfully tried to convert a reluctant Soviet government, to whom he, a former Czarist Lieutenant General, had lent his services for purely patriotic reasons. He was Member of the State Planning Commission, Chairman of the Chemical Administration of the Soviets, and of many other technical and scientific committees. In these capacities he traveled widely in Germany, Belgium, France, and England. It is very revealing to note how intent the Soviets were at times to establish friendly relations with such exponents of capitalistic production as the I. G. Farbenindustrie and similar concerns. In the end, however, those men who worked upon order of their government for the establishment of better scientific and technical relations with foreign countries were themselves viewed with suspicion and distrust and strictly supervised and curtailed in their scientific activities. Even a scientist of Ipatieff's standing and international fame was not free from suspicion, and, after several of his colleagues and coworkers had been "liquidated," he felt it safer to leave his beloved homeland.

Now it is our good fortune to have Ipatieff, the indefatigable chemist, working and teaching here. He is Professor of Chemistry at Northwestern University and Director of Research of the Universal Oil Products Company in Chicago. This last interesting chapter of Ipatieff's life is not dealt with in the present autobiography, but it may be hoped that it will be written in due time. For, much as the great Russian

chemist has already given to the scientific and industrial world, he has still more to give. He has amassed an immense chemical knowledge and has also acquired, through long and bitter experience, the true wisdom that transcends the limits of any particular science and is applicable to all. We can truly take to heart what he says in the closing chapter of his autobiography:

> A Government has the right to ask a scientist to aid in developing some process which may be of great importance to the nation's economic life, and a scientist is obligated to help if he possesses sufficient knowledge. But neither the Government nor the scientist should ever forget that most scientific developments come from research which is itself completely divorced from any practical application.

FRANCIS JOSEPH WEISS
Special Research Consultant
Sugar Research Foundation, Inc.

ACRES OF DIAMONDS

New Riches from the Soil. Wheeler McMillen. xii + 396 pp. $3.00. Van Nostrand. New York. 1946.

IN THE face of the impending starvation of millions in Europe, friends and foes alike, it is too bad the author of this book was not present at Potsdam to voice a strong protest against the unfortunate Allied edict condemning all German chemical nitrogen plants to destruction or to enforced idleness. Prior to the war, Germany accounted for 40 percent of the world's production of nitrogenous fertilizers using the famous Haber-Bosch process for fixation of atmospheric nitrogen. The major portion was exported to enrich the farms of other European countries.

Now, belatedly, wiser judgment has prevailed, and such plants as were not destroyed or dismantled are being reopened. Meanwhile, in response to frantic appeals for immediate aid from generals in command of the occupying forces, hundreds of thousands of tons of nitrogenous fertilizer are being exported from wartime synthetic ammonia plants in the United States, mostly at the expense of American taxpayers. The tragic explosion at Texas City of the French freighter *Grand Camp* originated in a cargo of ammonium nitrate destined for European relief.

Although the author emphasizes the transcendent importance of building civilization around a healthy agriculture, capable of producing ample foodstuffs, and praises the economic permanence which ensues, his main purpose is to portray the growth of chemurgic* industries and to stress their social significance. As editor of the *Farm Journal*, as joint founder and President of the National Farm Chemurgic Council, and as a practical farmer as well, Wheeler McMillen is exceptionally well qualified to do this. Admitting in his preface that he "is not a scientist . . . but perhaps a sort of evangelist," he points out that "twenty years ago [he] became convinced that mere law-passing could never assure a stable and prosperous American agriculture . . . the problem is not legislative but economic and scientific."

His faith in the limitless achievements of modern science for man's good is stimulating to those engaged in the profession, and reassuring to the general public. "The three great tools now available to agriculture which promise enlargement of human wealth," he concludes, "are the science of organic chemistry, the science of plant genetics and the art of the engineer."

"Probably about nine out of ten people in the world live and die in poverty," he continues. "This is not for lack of natural resources, but because of ignorance of

* *Chemurgic*, a combination of *chemi*, or "chemistry," from the black art of ancient Egypt, and *ergon*, or "work," from the fount of knowledge of ancient Greece. Coined by William J. Hale in his book *The Farm Chemurgic* (1934), its definition through usage is "to advance the industrial use of farm products through applied science."

them." He then follows with a wealth of convincing practical illustrations of chemurgic progress, particularly in the United States, which demonstrate that the author is a persuasive interpreter of science.

In philosophical vein McMillen challenges the reader with the logic of his observations:

> The vegetable kingdom reproduces itself. The mineral kingdom does not... agricultural communities a thousand years old can be found around the world. Extractive mineral industries leave ghost towns behind them: sound agriculture does not... ninety eight per cent of the material in the plant (annual or perennial) is the product of atmosphere and moisture, [plus a few mineral catalysts].

He paints a glowing picture of the hitherto unsuspected wealth of the vegetable kingdom as a permanent source of supply of raw materials for industry.

While commending governmental agencies for their sponsorship of fundamental chemurgic research and development through various state colleges and universities and through the four Regional Research Laboratories of the U. S. Department of Agriculture, the author strongly advocates private competitive enterprise as the best medium through which to translate the fruits of such research into commercial application. This will better assure the economic soundness of the program. His advocacy of incentive payments by the Federal government to encourage the domestic production, where feasible, of agricultural commodities now being imported (no doubt a wartime necessity) will not be accepted favorably by everyone; but he certainly is on firm ground when he proposes incentive payments to the farmer for planting *"soil-improving and erosion-preventing crops."* With one-half our topsoil already washed into the seas, this remedy is sound insurance for future generations.

The last chapter is a plea for greater production as a force for peace. Though not attempting to be exhaustive, the author maintains that the principal basic cause of war is want of food and goods. These deficiencies, he urges, can be supplied by men of science if world statesmen will turn their attention from political remedies to economic preventives and use the tools modern science offers. "Growing things and making things pay better than taking things!"

The book is recommended to scientists as an example of lucid interpretation easily understood by the multitude—an example that might well be emulated—and to the general public as a tonic in these days of confused talk and thought. The farmer will find new hope in it, and the student might well consult it before choosing his vocation.

CARL B. FRITSCHE
Reichhold Chemicals, Inc.
Tuscaloosa, Ala.

PLAIN AND SIMPLE FAITH

Papago Indian Religion. Ruth M. Underhill. vi + 359 pp. $4.50. Columbia. New York. 1946.

FOR those whose curiosity would lead them to ask what a primitive religion is like, this readable and authentic account is highly recommended. Dr. Underhill has long been known for felicity of style, simplicity of presentation, and faithfulness to the record. One noteworthy characteristic is the large number of song and speech texts in fluent but obviously close translation.

The Papago occupy the desert lands of the Arizona-Sonora border. With the cognate Pima to the east, they comprise a somewhat distinct linguistic group in our Southwest, yet their culture is in general Southwestern (rather than Mexican or wholly distinct) and specifically of the Gila-Colorado River-Cáhitan subvariety. Until recently our lack of precise knowledge of Pima-Papago life left a bad gap in an otherwise reasonably thorough survey of South-

western tribes. Dr. Underhill's earlier *Social Organization of the Papago Indians* (1939), with the present volume and such data on their material existence which she may still have unpublished, will block in part of that blank area. We wish for just such excellent material on the Pima. Russell's *The Pima Indians* (1908), with which we make shift, is hardly more than an inconsiderable commentary on a museum collection, with detached, unexplained oddments —indeed, Dr. Underhill's record on the closely related Papago often clarifies the mystery of the Russell items.

Papago religion has no single, coherent core; hence the ethnographer must draft its subject matter as a set of uncoordinated beliefs and practices. The origin myth, as the author points out, does not serve as a cohering base for ritual (as it does for Navaho), though there is some counterflow between the two. The lack of relation stems first from the diversity of versions, each peculiar to the several Papago local groups, ostensibly learned by rote but subject to the vagaries of the accredited narrators, and, again, from the absence of a body of ceremonialists (as among the Pueblos) concerned with standardization and interested in welding myth and ritual into a consistent body of theological doctrine and practice.

The supernaturals of myth are not those of ritual, either in impersonation or as the target of prayer. Here function the ancient divine bestowers of ceremonies, the rain-controlling divinities, and animal spirit guardians who may be beneficent or otherwise, according to occasion. Contact with the supernaturals was through group ceremonies, directed by priests and for the common good, and by individual quest for power to overcome life's difficulties. In general, whatever the immediate need for which help was sought, all contacts were thought of as ultimately for the bringing of rain. The rites of the individual were those occasions when specific supernatural power was sought: the prime occasion was during the course of purification from defiling contact (as with the magically malevolent enemy) under the aegis of ritual instructors, when the supplicant was most favorably disposed to the reception of benefits via a vision from the spirit helpers. Some uniqueness of Papago religion lies in the utilization of these occasions—paralleled in neighboring tribes—as opportunity for the power quest.

Most of the ingredients of Papago religion are common to other tribes of the subarea, and, indeed, many are widely distributed over the Southwest. The Papago Rainmaking Ceremony, for example, is the familiar "wine"- (suhuaro) drinking celebration of neighboring tribes. It is here ritualized and rationalized on the principle that all ceremonials are directed toward rainmaking. "The idea is that the saturation of the body with liquor typifies and produces the saturation of the earth with rain. Every act of the procedure is accompanied with ceremonial singing or oratory describing rain or growth" (p. 41). The unique Papago (and Pima?) contributions to this elaborate complex of celebrative rites are rainmaking as motive, the presence of the village fetishes, a circling dance, perhaps the set speeches, and four representatives of different villages typifying the four rain supernaturals placed cardinally and accorded reverence. Yet there is little hint in this volume that the suhuaro-drinking celebration was common among the Southern and Western Arizona tribes and was, in fact, a Northern extension of a widespread Mexican drinking and narcotics complex.

It was not the author's intention to offer a comparative survey to place Papago religion in relation to surrounding cultures—save with regard to the Prayer-Stick Festival—but a Southwestern ethnographer is constantly stimulated to try his hand at it. The more so since Dr. Underhill, probably without intent, often phrases her material

as though unique to the Papago and derived by them in reaction to the impinging needs of an inhospitable environment and developed out of the traditional motivations they ascribe to their rites. To be sure, she frequently offers some parallels of minor items to other Southwestern groups, almost always to the Pueblos. But one would say that while these are justified, they tell only a partial story of relationships; for many of the elements—whole ceremonies, ritual components, minor practices—affiliate as well with groups other than the Pueblos, geographically placed in quite other directions.

LESLIE SPIER

Department of Anthropology
The University of New Mexico

BRAVE NEW WORLD

UNESCO: Its Purpose and Its Philosophy. Julian Huxley. 62 pp. $2.00, cloth; $1.00, paper. Public Affairs Press. Washington. 1947.

UNESCO's main concern is with peace and security and with human welfare, in so far as they can be subserved by the educational and scientific and cultural relations of the peoples of the world." Julian Huxley, who was the Executive Secretary of the Preparatory Commission of UNESCO, and who is now the Director General of the organization, attempts to formulate briefly the basic philosophy for a United Nations Organization charged with the tasks outlined in the above quotation.

Huxley writes as a biologist, philosopher, and social scientist, in the great tradition of the family of naturalists of which he is a worthy descendant. He sees UNESCO as the next big step in the intellectual evolution of the human race. In contrast to the organizations that functioned under the League of Nations, UNESCO must go to the people and prepare them for universal service as citizens of the world. UNESCO takes the lead, as the world moves gradually—as in the end it must, if we are not to perish—toward political unification. UNESCO should help to achieve the maximum progress in the minimum time, and it is for this reason that Huxley urges for UNESCO an evolutionary background.

Huxley has no illusions about the ability of the entire human race to take full advantage of the total available worldpool of knowledge, art, and culture. UNESCO should not aim at quantity, to the detriment of quality, but it should provide to all who desire it an opportunity to share in the common pool. We need on a world-wide scale the same equality of opportunity that we are striving to achieve on a nation-wide scale under our democratic system. UNESCO must "let in light on the world's dark areas."

The pamphlet is divided into two parts. In our brief summary we have quoted from the first part, that dealing with the background of UNESCO. This is a moving document that should be read with care and pondered over by all who wish to see the United Nations succeed. The second part, which describes the program, is not on the high level of the first part. It is a not-too-happy blend of basic philosophy and of itemized programs, which left this reviewer confused and dissatisfied. UNESCO has a fine program of which the major portions are rehabilitation of schools and institutions in war-devastated areas; a world-wide attack on the problems of illiteracy; a program of promoting international understanding through teachers' conferences, exchanges, and the like; and the over-all study of the potentialities of the Hylean Amazon basin. These have not been adequately treated in the pamphlet.

Huxley's discussion is a valuable one, but it would be unfortunate if one's only contact with the program of the new organ-

nization should be through this booklet. Those who are really interested in learning of the plans and projects of UNESCO should supplement the reading of Huxley's pamphlet with other material that is now available. Copies of the report published by the U. S. National Commission on UNESCO, the Draft Reports of the UNESCO Congress in Paris of last year, and a report on the National Conference on UNESCO held at Philadelphia in March of this year can be obtained by writing to the Office of the UNESCO Relations Staff, State Department, Room 304, Walker-Johnson Building, Washington 25, D. C.

Bart J. Bok
Harvard College Observatory

THE SEAR AND YELLOW LEAF

Aging Successfully. George Lawton. xiv + 266 pp. $2.75. Columbia Univ. Press. New York. 1946.

In the past few years an increasing interest has developed in the "problems" of old age. Dr. Lawton attempts in this book to present a readable discussion of important issues, aimed at the older reader himself. Emphasis is placed on aging as a process of change, with its advantages and disadvantages and its realistic opportunities. By making a reasonable effort old people can adapt themselves quite adequately to their new circumstances if they have been developing a wide range of interests and abilities in youth.

Discussion is matter-of-fact and straight to the point. Proposed solutions are based on the author's wide clinical experience and a knowledge of pertinent scientific literature. This book may well serve as a handbook of later maturity, adapted to the interests and reading ability of its audience.

R. B. Ammons
Department of Psychology
University of Denver

HERPETOLOGY FOR AMATEURS

Reptiles and Amphibians of the Northeastern States. Roger Conant. 40 pp. $1.00. Zoological Society of Philadelphia. 1947.

Mr. Conant, Curator of the Philadelphia Zoological Garden, has constructed a nontechnical resume of the snakes, lizards, turtles, frogs, toads, and salamanders of the Northeastern states that furnishes instant identification for all these interesting animals through photographic illustrations of every species. In addition, he has furnished a check list of species and interesting chapters on each group; a chapter on the treatment of snake bite; another for the identification of baby turtles, which differ surprisingly from their parents; and a chapter on the care of captive specimens.

This pamphlet is recommended for the individual who keeps pets of this nature, the observant hiker, Boy Scouts, science teachers, and nature enthusiasts.

The size of the pamphlet and texture of the paper make this edition a desk item. It is to be hoped that Mr. Conant will publish a pocket-sized field guide, using the same excellent illustrations and descriptive matter.

Chapman Grant
San Diego, Calif.

THE PLANTS THAT LEAD A DOUBLE LIFE

The Nature and Prevention of the Cereal Rusts as exemplified in the Leaf Rust of Wheat. K. Starr Chester. xiv + 269 pp. Illus. $5.00. Chronica Botanica. Waltham, Mass. Stechert-Hafner. New York. 1946.

Wheat is probably the most important of man's food crops, and the three rusts that attack it (stem rust, leaf rust, and stripe rust) are the most serious diseases affecting that crop. Despite the immense amount of research work done on

these rusts in English-speaking countries in the past three decades, there has appeared in English no monographic treatment of any of the cereal rusts comparable to *Der Schwarzrost*, published in Germany in 1937, or Naumov's *Cereal Rusts in the U. S. S. R.*, produced in Russia in 1939.

Dr. Chester's book fills this want in part, but in part only, for despite the title *The Cereal Rusts*, by which it is advertised and sold, it is largely confined to one of the three rusts—leaf rust of wheat.

This restriction of scope is, however, actually an advantage from the point of view of the student of the rusts, for it has permitted a thorough and exhaustive treatment of the subject such as would not have been possible if the other cereal rusts had been included.

To most people, at least in North America, rust of wheat means stem rust, partly because of the news value of its swift and often devastating epidemics, and partly because of its well-known association with an entirely different host plant, the common barberry. The author has nevertheless made a convincing case that in the world as a whole leaf rust is the more destructive of the two. Because of the insidious quality of its parasitic behavior, the true importance of leaf rust was not recognized in North America for many years after scientists had turned their attention to the control of stem rust. In countries where stem rust was relatively unimportant this recognition came sooner. In Germany and the U. S. S. R. scientific attention has been concentrated for many years past on the control of leaf rust. Although control of this, as of other cereal rusts, must come chiefly through the breeding of rust-resistant varieties, a thorough understanding of the nature and behavior of the rust organism is an essential prerequisite. This realization has led to intensive investigations concerning this rust in most of the important wheat-growing countries of the world.

The extensive literature on leaf rust, scattered through the scientific and agricultural journals of a dozen or more countries, is admirably summarized in Dr. Chester's book. Particularly valuable is the review of the numerous and many-sided investigations carried out in the U. S. S. R., with which the author has made himself thoroughly familiar by his translations into English of a large number of Russian scientific papers. Well summarized also are the important studies of Gassner (to whom the book is dedicated) and his associates, who have contributed much to our too-scanty knowledge of the chemical basis of rust resistance and susceptibility. It might be mentioned in passing that both the German and the Russian investigators have placed a greater emphasis on fundamental studies than has been the practice in English-speaking countries.

The book is by no means, however, a mere summary of the literature concerning leaf rust. The author's whole handling of his subject is pervaded by a strong sense of logic which has led him, wherever possible, to create order out of chaos. In several instances he has ransacked the literature for data bearing on some point of importance and has built up tenable conclusions from numerous scattered experiments and observations. One such case is his establishment of a definite relationship between leaf-rust intensity at different stages in the growth of the wheat plant and the resulting loss of yield. Another of the seemingly chaotic situations he has tackled is the vexing question of the specialization of the rust into a large number of pathogenically distinct entities or physiologic races. His proposal that the 129 races in the "International Register" be grouped on the basis of similarites into 44 race groups cannot be resisted on logical grounds and will, if it gains general acceptance, simplify considerably the task of race identification. The identification of physiologic races is, however,

essentially a service to plant breeding, and on its serviceability in that respect the scheme will stand or fall.

Though the book is primarily written for the specialist in plant diseases, the author has nevertheless kept the elementary student in mind and, for his benefit, has explained most things from the ground up. All in all, it is the most notable book of its kind that has been published in English for many years past.

There is a bibliography of about 500 references, as well as adequate author and general indices. The editing conforms to the high standard set by Frans Verdoorn for the *Annales Cryptogamici et Phytopathologici*, to which series this book belongs.

T. JOHNSON
Dominion Laboratory of Plant Pathology
Winnipeg, Manitoba, Canada

REVERIES OF A NATURALIST

The World Grows Round My Door. David Fairchild. xii + 347 pp. Illus. $5.00. Scribner. New York. 1947.

THERE is no preface for this book, which is perhaps reasonable, since it is essentially a book of reminiscences. The author, however, does say in his first chapter that he hopes "to show . . . that there is a fascinating world of living things. . . ."

In spite of its title, the book is primarily about people, the Fairchilds themselves, their children and their children's children, and the endless stream of the great and the near-great who have known the Kampong or have had a share in the Florida and other phases of the author's life.

Not content with this, Fairchild goes back to his boyhood and briefly sketches the early years in Michigan and Kansas, school and university days, and then that astonishing first trip abroad. The impact of these first impressions is recounted with astonishing naiveté, and indeed one might say that this amazing capacity for looking at new sights with uncritical enthusiasms has never perished.

To a plantsman, the book will be most unsatisfying if he wants to read about plants, although the many fine pictures, most of them taken by the author, will console him somewhat. Endless things are mentioned, but very little is said about them. Palms, tropical vines, succulents, citrus fruits, kudzu, soybeans, sausage trees, bael fruit, mangoes. avocados, mangosteens, all remind us of the catholic tastes of the author and of his puckish pleasure at the discomforts of those who had to eat whatever he presented. (It is notable that children most often refused—and were least censured.) No full pictures emerge, however, either of the Kampong as a whole or even of snatches of the native landscape from which the treasures have been wrested.

The wideness of his travel is recorded in the mention of such far-separated places as Japan, France, Java, the Gold Coast, French West Africa, New Guinea, Guatemala, Colombia, the Celebes, Mexico, Brazil, Sumatra, New Zealand, Nova Scotia. Many more could have been named.

The growth of the Kampong, Fairchild's present home in Florida, is described at considerable length, but more could well have been said, since it is an estate with special significance: it reflects not only the traveled background of the author, but also special adaptations to the local site and conditions that are particularly well done.

If we will cast aside all preconceived notions as to what the book should or might be and follow "DF," as we all affectionately call him, wherever his errant fancy may suggest; if we will accept his kaleidoscopic enthusiasms one after another; if we will indulge his penchant for the personal and smile at his passion for the beauty of the moment while he labors to record forever the person and his deed—if we do all this, we can follow intimately in many details

the full and varied life that the author still enjoys.

B. Y. MORRISON
Bureau of Plant Industry, Soils, and Agricultural Engineering
U. S. D. A., Beltsville, Md.

SHORT PERIOD SOLAR VARIATIONS

The Sun's Short Regular Variation and Its Large Effect on Terrestrial Temperatures. C. G. Abbot. 33 pp. 30 cents. Smiths. Mis. Coll., Vol. 107, No. 4. Washington. 1947.

AFTER his retirement in 1944 as Secretary of the Smithsonian Institution, Dr. C. G. Abbot, now a Research Associate of that Institution, has continued his work of correlating the variations in the solar constant with the temperature variations at the earth's surface. His latest work begins with the following statement:

> I propose to show that there is a regular period of 6.6456 days in solar variation, and that terrestrial temperatures respond with changes from 2° to 20° F. in exactly the same average period of recurrence. While the sun's variation appears to be perfectly regular in phase, always recurring on the day predicted, the terrestrial responses come sometimes for a month or more in succession from 1 to 3 days early or late. This, which by mechanical analogy we might call backlash, is doubtless the circumstance which hitherto has prevented meteorologists from recognizing the nature of this large temperature variation. When examined with the knowledge of the 6.6456-day solar period, the temperature effect is indeed so strikingly obvious, as the reader may see from figures 3 and 5, that no one could doubt that it is both real and a major element in weather. Meteorologically, this regular average periodicity appears to be a new discovery. It is not to be confused with temporary weather periods, ranging from 3 to 7 days in length and changing their phases from time to time, which have been discussed by Clayton [*et al.*].

In 1936 Dr. Abbot published two papers on the dependence of terrestrial temperatures on solar variation. The amplitude of the temperature was about 10°F., and the variation of the solar constant was about 0.7 percent of its value. Meteorologists, physicists, and astronomers have to this day remained skeptical as to whether the Smithsonian observations of the solar constant really were accurate enough to establish solar variations from day to day. In his latest study Dr. Abbot has exclusively used the accurate determinations of the solar constant made at Montezuma, Chile, from 1924 to 1944. In his previous analysis only the larger variations could be discerned individually, but in this recent study excessive changes were omitted as spurious. The period in the solar variation was determined with high accuracy, but the amplitude was found to be only about 0.13 percent of the solar constant.

The amplitude of solar change is so small, compared to the average amplitude of temperature change associated with the 6.6456-day periodicity, that Dr. Abbot is inclined to attribute the terrestrial temperature effects to some indirect action, such as fluctuations in the amount of ozone in the higher atmospheric strata. Since the phases of the temperature recurrence remain almost unchanged in any one month, and the variation of amplitude is not often excessive within that interval, temperature forecasts of the order of a month in advance appear to be feasible with the aid of the cycle newly discovered by Dr. Abbot. Meteorologists now have a chance of testing the practical value of "Abbot's Cycle."

GUSTAF STROMBERG
Pasadena, Calif.

Comments and Criticisms

JOSÉ LONGINOS MARTÍNEZ

The article by Carlos E. Chardon in the March SM on the Naturalists of Tropical America was of great interest to me because I have always felt that the contribution of the Latin Americans themselves to the natural history of the lands which they settled has been too much neglected by the historians of science One must suppose that the omission of the names of Francisco Herrera and Carlos de la Torre can be accounted for by the fact that the former was recently the subject of an illuminating article in the SM and the latter is still alive. Perhaps they will be covered in the book which the author contemplates writing.

There is one pioneer naturalist whose career is not covered in this article and who has been consistently neglected by practically every writer since his day. I am referring, of course, to José Longinos Martínez, as he is commonly known, though there is sufficient documentary evidence to indicate that his Christian name was Joseph. In the Archives of the Indies at Seville there is an invoice of mammals, birds, and reptiles which he sent back from San Borjas, in Baja California, to the Archbishop of Seville in 1792. In a contemporary newspaper published in Mexico City is an announcement of the opening of a museum of natural history under his direction, in which the plants and animals are arranged according to the Linnaean system. And a document in the same city signed by Fernando Eliya states that on his return voyage he picked up the famous botanist Joseph Longinos Martínez at an unnamed California port (which we now know to have been San Diego) and disembarked him at San Blas in 1792.

Some years ago Dr. Henry R. Wagner discovered a manuscript copy of Longinos' account of his travels, which is now in the Huntington Library, where I have examined it. According to Dr. Lesley Byrd Simpson, who translated it, it is not the original, but the work of a copyist, whose ignorance and carelessness are shown by the large number of grammatical errors, misspelled words, etc. in the narrative. Further, it is inconceivable that Longinos could have visited the localities which he names in the order set out in the document For this reason the manuscript was at one time considered to be a rather clumsy forgery, but shortly after its publication Mrs. Winifred Davidson, the historian, discovered on the baptismal record of the San Diego Mission an account of the baptism of an Indian boy, whose father was the famous botanist Joseph Longinos Martínez, "naturalized by his majesty." The fact that Longinos was a naturalized citizen is important, for it explains his disdain for the Spanish Franciscans and his admiration for those from Catalonia and Germany. If, then, he was foreign-born of what nationality was he? The fact that his paternal patronymic was Greek suggests to me that he may have been of mixed Greek and Spanish parentage—but that theory is as yet an unproved speculation. His knowledge of the Linnaean system suggests that he may have been a student under the Swedish master, but his name does not appear in the list of pupils of Linnaeus published by Dr. Jackson of the Linnaean Society.

The Longinos narrative suggests that he was a keen observer of all phases of nature, not only as botanist and zoologist but also as mineralogist and anthropologist. He was the first to record observations on the life, habits, and thought of the California Indians, as well as the first to make a chemical analysis of the numerous mineral springs of the state. At times given to exaggeration (what Californian is not?), he nevertheless made detailed and complete observations. Yet today he is practically forgotten, the only attempt to preserve his memory, as far as I am aware, besides the translation of the anonymous copyist, being a bronze plaque on the wall of the Junípero Serra Museum of History in Presidio Park in this city.

It is my hope that Dr. Chardon will be able to unearth further data about Longinos in his forthcoming work, as well as about such significant writers as Molino and Hupé, who exist today only as names in bibliographic references.

Joshua L. Baily Jr.

San Diego, Calif.

GEOLOGY SLIGHTED

I realize that the excellent article by Dr. Brandwein on "The Selection and Training of Future Scientists," which appeared in the March Scientific Monthly, is descriptive of a practical application of the scientific method to precollegiate instruction. However, to scientists whose major field of interest is geology, it must be a disappointment to find no mention of that earth science, a most basic one, as being included in preliminary work done in the training of "future" scientists in the Forest Hills

High School It is believed that there is as great a need for the education of future scientists in geology as in any other field. The inclusion of geology in a program such as that outlined by Dr. Brandwein is, because of the very nature of that science, practical, logical, and highly desirable. An interest in rocks and minerals is inherent in the average teen-age student, and some encouragement of this interest along the lines suggested in the article will do much to develop those students best fitted for more advanced training and a career in that science, and to provide a broadened vision for those who eventually go into other fields The future role of geology in the various forms of human endeavor may be expected to be a greater one, and a precollegiate program in this respect seems highly desirable for many reasons.

THOMAS G. MURDOCK

Raleigh, N. C.

JUNIOR ACADEMIES OF SCIENCE

I was very much pleased with the summary of Junior Academies of Science published in THE SCIENTIFIC MONTHLY [April 1947]. The movement has great possibilities. Texas organized in 1935, and in 1937 I presented the first charter from the Texas Academy of Science. In the ten-year interval the organization has greatly increased its membership and activity. The local Galveston club has grown to about five times its birth weight. For several years I gave a scientific book as a prize to the leading member at the end of the year. This year I am offering membership in the A.A.A.S. and a subscription to THE SCIENTIFIC MONTHLY in the hope that others may do likewise. Miss Rose Mary Strain is the recipient this year. Her interest is psychology.

Texas Academy of Science is almost unique in having a Collegiate Academy for undergraduates as a feeder to the Senior group. The Collegiates and Juniors each have their own publications, and their own meetings at the time and place of the annual meeting. They are free to attend any meetings they choose.

This year Texas Academy of Science is attempting to establish permanent headquarters and hire a business manager and editor. A central theme has been adopted for the Academy by approval of a Council on Conservation, with each Councillor serving as a center for collection, presentation, and publication of data in a specific field. The project is of considerable interest to Governor Jester. The Council will continuously survey—

1. The health of the people, physical and mental.
2. The genetic composition of the state with attention to eugenic and dysgenic factors.
3. The effect of social and economic institutions and ideas on the public welfare.
4. Conservation of soil.
5. Water resources.
6. Oil and gas.
7. Sulphur and minerals.
8. Grazing and forest lands.
9. Marine resources.
10. Wildlife.
11. Archeological and paleontological sites.
12. Parks.

JOHN G. SINCLAIR

Medical Branch
The University of Texas

I have found THE SCIENTIFIC MONTHLY so much more valuable and interesting recently than heretofore that I cannot refrain from writing to express my appreciation for its great improvement.

It is gratifying to note that the magazine now gives increasing attention to the general problems of science rather than dealing entirely with specialized fields. To the extent that specialized fields are treated, I am happy to see that the physical sciences are beginning to receive a reasonable share of the space.

My profession is physics; one of my avocations is acting as adviser to the Junior Astronomy Club, Hayden Planetarium, New York City. In this connection, I was especially interested in the articles relating to junior science in the April issue. Along the lines suggested by you in "The Brownstone Tower," I have felt that youngsters interested in science would find THE SCIENTIFIC MONTHLY interesting and valuable and I have made my copies available to Junior Astronomy Club members. It seems to me that many A.A.A.S. members could be encouraged to spread the use of their copies through school libraries and in other ways. Another method of getting SM into the hands of youngsters would be the establishment of junior or student membership in the A.A.A S. at reduced rates.

JAMES B. ROTHSCHILD

Wharton, N. J.

Technological Notes

Must Be More than Spectacular. An idea with novelty constitutes an invention, but hard work and attention to painstaking detail are generally necessary for the innovation to be a success. Often we hear only of the "spark of genius," as a court once described it, and forget the dogged details.

Dusting insecticides on growing crops by airplane is novel and romantic. Young Lindbergh can come swooping out of the clouds, and straightway the boll weevil is vanquished—or so we may think. But Dr. George Decker, of the Illinois Natural History Survey, reminds us that it's not so simple. Research, he says, is necessary to devise the best type of plane to spread the compounds properly, and the materials themselves need to be specially formulated for that method of application.

The problem touches farmers, insecticide manufacturers, airplane designers, and the Civil Aeronautics Authority. Landing strips should be handy. Planes and pilots must not be jeopardized by unsafe flying conditions. Dusts shouldn't drift off the crop being sprayed or settle heavily down the middle of the swath. Such problems have to be licked, says Dr. Decker, or people will lose confidence in this way to fight insect pests.

Home Hardware. Nowadays there is no excuse for ignorance. So many agencies, government and private, furnish information in attractive packages that anyone can be enlightened on almost any subject. The only drawbacks are lack of filing space and shortage of time for reading and attention.

The reason for the foregoing observation is "Hardware for the Home," an illustrated circular of business-letter size already punched for binding, one of a series on small homes published by the University of Illinois. The University emits a publication in this series every five days, the mailing statement says, so that one agency furnishes an enormous amount of enlightenment.

The hardware in this case is such articles of convenience as locksets and doorstops. Check lists and drawings show just what is needed and how it will look and the method of installation. The newest in locksets is the one that can be installed by just cutting a notch in the door, though the tubular lock is probably the most popular type. There is a reminder that $25 extra will generally buy the very best in hardware for a house, and that solid brass and bronze wear excellently and become more beautiful with use.

After Cataract. Eye operations, which to the layman, at least, are miracles of skill and delicacy, in about a quarter of the cases are removal of the crystalline lens to relieve cataract. The person who has lost the lenses of his eyes (called an aphakic) must use glass substitutes. What might seem to be an advantage, according to an American Optical Company release, is that the aphakic can see by ultraviolet light. The lensless eye is 1,000 times as sensitive as the normal eye to light of 365 millimicrons. However, the u.v. may be injurious. American Optical has announced a new lens that strains out the u.v. A further advantage claimed is that the new lens, made thin around the rims, weighs only half as much as the usual thick lenses supplied patients who have had cataract operations.—M. W.

The Brownstone Tower

In an editorial note on page 89 of the July issue I introduced a new monthly page entitled "Technological Notes." I pointed out that these notes on the passing scene are being written by "a friend," whom I now present to our readers. M. W. stands for Merrill Weed, a friend indeed to me and the SM. I met him first before the war when I was Professor of Entomology at The Ohio State University and he was Editor of the publications of the O.S.U. Engineering Experiment Station. He also wrote a four-page monthly leaflet called *Science and Appliance* for the O.S.U. Research Foundation. *Science and Appliance*, which he continued to write while away from the campus in military service and which he still carries on, became noted for its interesting information culled from many sources and for its breezy style. As some of the members of our Publications Committee were familiar with it, they did not hesitate to accept Mr. Weed's offer to write a page of similar material each month for the SM.

Every issue of the SM's volume 65 (July–December, 1947) will contain something on the Chicago Meeting of the A.A.A.S., December 26–31, 1947. In the September issue Dr. John M. Hutzel, our Assistant Administrative Secretary, will take our readers behind the scenes and describe the intricate preparations that must be made long in advance for each annual meeting of the A.A.A.S. In the October issue the special duties of the manager of a convention bureau will be described by the man who served in that capacity at the last Boston Meeting. The December issue will consist largely or entirely of contributions from scientists in the Chicago area and, of course, will stress the meeting and the scientific institutions that will serve as hosts.

In the heat of early summer Dr. Hutzel has been working furiously on preparations for this winter meeting. Those who read his forthcoming article may realize for the first time that an annual meeting is expensive, not only to the individual who attends it but to the organization responsible for it. It is estimated that the Chicago meeting will cost $35,000. Previous experience shows that expenditures for this meeting will exceed income by about $14,000. The A.A.A.S. no longer has a reserve for the absorption of such deficits. Therefore something must be done to make the meeting self-sustaining. Since the affiliated societies who meet with the A.A.A.S. do not contribute directly to the meeting expenses, it seems reasonable and just that all those who attend the meeting, whether members of the A.A.A.S. or not, should pay a registration fee sufficient to cover expenses. Consequently, the secretary of each cooperating society has been requested to propose to his executive committee that a resolution be passed requiring attendance at its sessions be restricted to those who register with the A.A.A.S. for the meeting. Responses from the secretaries have been favorable, but they must have the informed support of their members. Therefore we hope that every reader who attends the Chicago meeting will register, even though his society may not require it. In this equitable manner, with little cost to any individual, everyone present can contribute to the success of the meeting.

F. L. Campbell

THE SCIENTIFIC MONTHLY

VOL. LXV September 1947 NO. 3

THE FISH AND WILDLIFE SERVICE*

A SUMMARY OF RECENT WORK

By IRA N. GABRIELSON

Dr. Gabrielson (Sc.D , Oregon State) was the first Director of the U S. Fish and Wildlife Service, formed in 1940 by combining the Biological Survey and the Bureau of Fisheries. In 1946 he retired from government service and became President of the Wildlife Management Institute, Washington, D C. Since the time he entered the Biological Survey in 1915 he has been actively interested in the preservation of wildlife; the knowledge and experience he has thus derived from actual observation have made him an authority in this field.

WHEN *The Scientific Monthly* asked me to write an article on the principal accomplishments of the Fish and Wildlife Service during the period I was Director, first of the Biological Survey, and then of the present organization, I felt it would be an easy task. The attempt to evaluate the relative importance of various undertakings from a perspective somewhat removed from the immediate action has been revealing. As inevitably happens, many events that once seemed important have faded into relative insignificance. Each of these events may have been important at the time, and the very fact that a local victory had been won may have helped the general conservation program. In looking back, however, it seems that much of the significant progress made during the period 1935–46 lies in the intangible field of conservation.

In attempting to evaluate this progress I am entirely conscious of the fact that any results obtained were largely due to a fine staff, the numerous able and talented men who are completely devoted to doing a good job in the management of wildlife resources. Many of them have trained for this field of work and expect to devote their lives to it. Those who enter government service in this specialized field soon realize that the monetary compensation for their work will be relatively modest and that part of the compensation must come from the satisfaction of a job well done. There are many such persons in the Service; without their loyal and enthusiastic support little could have been accomplished. I am also aware that many conservation leaders throughout the land contributed much to the success of our efforts.

Shortly after "Ding" Darling resigned and left a considerably perplexed new Chief of the Biological Survey on the job, the first North American Wildlife Conference met in Washington. At that time I was

* All photographs courtesy of Fish and Wildlife Service, U. S. Department of the Interior, Washington, D C.

asked to prepare a talk entitled "A National Wildlife Restoration Program." The talk given was the result of the combined thinking of the personnel of the Biological Survey. It outlined in seven points a National Program. There seems no better way to analyze the accomplishments of the Service during the past ten years than to review them against the background of this program:

The first need of wildlife is land; it is a basic essential. Birds cannot nest on the wing, nor can animals reproduce on the run. They must have places to live, to find food, shelter from the elements, and cover for escape from their natural enemies. The completion of a program of restoring 7,500,000 acres of marshland for waterfowl, outlined by Darling, was advocated Federal primary refuges for major wildlife species were also recommended.

The second need outlined was close cooperation between the Federal and state governments. This involved, first, cooperative research, demonstration, and educational programs between states and the Federal government. The existing ten cooperative research units were a part of that program The provision of a wildlife extension mechanism for getting information into the hands of people on the land was also advocated. Second, the adoption by the Federal government of a program to help finance state wildlife restoration programs was advised.

The third major proposal suggested a closer coordination of Federal activities, to make the government's conservation work more effective It was pointed out that little difficulty was experienced in securing cooperation between the principal conservation organizations but that there was great lack of correlation in the Federal government in determining over-all effects of impoundment or drainage operations, mosquito control, dam-building, and other activities of Federal agencies.

The fourth point urged the recognition of wildlife by land-management agencies both public and private. It was emphasized that the future of wildlife in the country was tied absolutely to the land and that the land managers will, in the final analysis, determine the fate of wildlife.

The fifth point stressed the importance of control of pollution. It was pointed out that pollution does vitally affect birds and mammals as well as fish and other forms. It threatens the very existence of aquatic vegetation, the small aquatic insects, the mollusks, and the crustaceans on which our waterfowl, game fish, and water-loving mammals depend. The prevention of new pollution and correction of existing pollution are, therefore, of vital importance.

The sixth point underlined the importance of adequate wildlife research programs. While there is much information on which a better wildlife administration can be based, there is still much to be learned. Also stressed was the fact that constantly changing conditions will require new information and new techniques to meet new problems.

The seventh point emphasized the fact that no wildlife program can be complete without provisions for the protection of the living forms involved. Protective regulations will always be necessary to preserve breeding stocks. Regulations to accomplish this should be based on the condition of wildlife populations rather than on the wishes or desires of the hunting public or on political pressure. It is impossible to manage wildlife intelligently by the slow processes of legislation, and the best mechanism yet developed has been to give to conservation administrative agencies the responsibility for making necessary regulatory changes.

After ten years' effort to accomplish the major objectives, this still seems a good program. If the program were to be written now, doubtless more emphasis would be placed on the educational end. Not that other factors should be emphasized less, but as the years have passed it has become increasingly apparent that an educational mechanism, designed to get sound information into the hands of the men who are living and working on the land in a form they can understand and use is a vital part of the program.

On the same program on which the National Wildlife Program was presented, Frank T. Bell, Chief, U. S. Bureau of Fisheries, presented a similar plan for fisheries.

The future conservation program of the Bureau of Fisheries, [he said, in brief] requiring as it does the full coordination of Federal activities on the one hand, and liberal cooperation on the part of State governments and private organizations on the other, may be divided into two major categories. One is concerned with the conservation of food and game fishes of interior waters now largely used for sport and recreation by millions of our citizens, which I shall discuss under three headings: First, the protection of existing supplies; second, the develop-

ment or expansion of those resources; third, the reclamation of fishing waters The other category deals with the economic management of the commercial fish supply, including the stabilization of yield, rational exploitation of the supply, and wise use of fishery products

This was undoubtedly the product of the joint effort of the fisheries staff. Certainly it expresses the philosophy of many still with the Service. In discussing the conservation of food and game fishes of interior waters, the statement outlined the need for preservative regulations designed to coordinate the supply with the harvest. It pointed out the often disastrous effects of the development of water-power and other dams on rivers; the effect of industrialization and the accompanying industrial wastes dumped into the streams; the effect of irrigation on the salmon and steelhead, in the West; and various other factors, which in addition to the direct human harvest are interfering with the maximum possible production of fish in inland waters. A program of artificial restocking to the extent necessary was advocated, and the need for the rehabilitation of the waters destroyed by pollution was pointed out. Also mentioned were the growing difficulties caused by silt, which was affecting more and more rivers as soil erosion became more widespread.

In discussing the commercial fisheries the statement recommended more and better scientific work. It declared:

With few exceptions, in particular fisheries, one of the simplest principles of animal husbandry may be applied to the commercial fish stock, namely, that the individuals of any species should be marketed at the time when they are of the greatest economic value to the industry and to the consumer, and that they should be protected at the time when they are of the greatest biological value to the species as brood stock. Specifically, this means that fish should not be taken until after they have passed the stage of most rapid growth and until they have spawned a sufficient number of times to assure continued productivity. Thus, in general, small and immature fishes should remain in the water to complete their growth and deposit their eggs After maturity has supervened and the growth rate has fallen, they may, in general, be marketed with the greatest profit.

This statement of the basic philosophy of the Bureau of Fisheries provides a background for judgment of the operation of the Fish and Wildlife Service after the two bureaus were consolidated in 1940. It is a human failing to look back wistfully at what might have been, but every conservationist must regret that the war put a sudden stop to what was probably the soundest conservation program the nation has yet undertaken.

For example, the ten Cooperative Wildlife Research Units, maintained by the American Wildlife Institute, the Fish and Wildlife Service, and the game departments and agricultural colleges of the ten cooperating states, were only well started when the war stopped many of their activities. The same thing might very well be said of the Pittman-Robertson Act, as the Federal-Aid-to-the-States program is commonly called. This program was just well organized and ready to go at the time war broke out. Almost immediately restrictions on materials and the draft of trained manpower quickly slowed down all projects that were not stopped entirely. In neither case did these two undertakings show the results that could rightfully have been expected from them under normal conditions. Likewise, the research programs in both wildlife and fisheries fields were abruptly halted, often on the very edge of fruitful production, by the diversion of the manpower into the armed forces or other war services. No one can ever compute the total loss, but the losses in new information and in developing additional trained men alone were staggering. Little or no progress was made in the over-all long-range program of conservation during the war years. In fact, most conservation organizations felt

themselves lucky if they did not lose too many of the precious gains that had been made under more favorable conditions. It is too soon to say how long it will be before the work can be resumed and gain the momentum that it had acquired over the years preceding December 7, 1941.

The single most important gain, it seems to me, in conservation of natural resources has been the greater public understanding and support of sound basic principles. As a result of constant discussion and study there is a clearer understanding in the minds of technicians, as well as in those of a growing portion of the general public, of the fact that soil and water conservation and wildlife management cannot be separated. They are different phases of the one big job of managing our lands and waters to preserve their productivity indefinitely and to secure the greatest possible annual return. It makes little difference whether it is in terms of tree or crop growth, wildlife or grasslands, fisheries or fur, if the crop taken is so great as to destroy or deplete the resource or to deplete the soil and water producing them, it is exploitation, not management. For every person who understood this fact ten years ago, there are thousands who now understand it at least dimly. Though millions more should be informed, the progress is gratifying, and the volume of public support for sane and sound programs is much greater than it was in 1935.

In the wildlife field significant progress has been shown by development of the Federal-Aid-to-the-States wildlife program under the Pittman-Robertson Act; the building of the National Wildlife Refuge system; the development by research of better management methods; the development of a cooperative working relationship with the Army Engineers and the Reclamation Service, so that for the first time the Fish and Wildlife Service and biologists had a chance to sit in on the planning of impoundments; the consummation of the Migratory Bird Treaty with Mexico, including numerous species that were not covered by the previous convention with Canada; and the establishment of the Patuxent Wildlife Research Refuge.

In the fisheries field considerable progress has been indicated by the development of the Little Port Walter Salmon Research Station in southeastern Alaska; by development of new techniques in fisheries research; by the vast job of salvaging the salmon runs that formerly spawned above Grand Coulee Dam in the Columbia; by the demonstration that sane management can restore even a depleted oceanic fishery, given by the International Fisheries Commission in handling the Pacific halibut fishery; and by the development of biological standards of water purity. Finally, the increase in accom plishments reflected in public interest and support may be measured by the comparative appropriations available for wildlife and fisheries work for the fiscal year 1936 and those for 1947. Including duck-stamp funds, approximately $4,500,000 of regular funds were available in 1936, as compared with more than $12,000,000 in 1947. Many of the increases have gone into increased pay rates provided by Congressional action, but the totals do indicate real public recognition. Most of the accomplishments came prior to 1941, but despite the loss of construction funds during the war years, Congress has been disposed to support this work.

WILDLIFE PROGRAM

Land for wildlife. On July 1, 1935, there were 6,100,020 acres in established wildlife refuges administered by the Biological Survey; about two-thirds of the acreage was in Alaska. As of July 1, 1946, the total number of refuges was 291, with an aggregate of 17,819,495 acres Of these, 271 refuges, with 9,889,856 acres, are in the United States. All wildlife is protected on these refuges, but some units are for special purposes. At the

Photo by Francis M Uhler

FOOD HABITS LABORATORY, PATUXENT RESEARCH REFUGE, MD.

present time 201, with 3,213,658 acres, are classified as migratory waterfowl refuges; 49, with 91,483 acres, mostly small islands are for colonial nongame birds; 16, with 10,642,015 acres, are for big game; 24, with 3,870,156 acres, are for migratory birds and miscellaneous forms of wildlife; and 1, the Patuxent Research Refuge, of 2,623 acres, is maintained entirely for wildlife experimental purposes. This land has been purchased from emergency funds and duck-stamp receipts, received by gift, or has been taken from the public domain. Much of it is relatively undeveloped from a wildlife standpoint and can be made more productive as funds become available. Even when money is available, it takes time to get the full biological advantage of water impoundments, plantings of various food plants, and other management measures that are used in building lands toward the greatest possible wildlife production.

One who did not live through the period of acquisition and development of these lands in the hectic days of the late thirties can have little conception of the immense volume of work required before such a program can be accomplished. Much of the acquisition that came after 1935 was due to the program initiated by Darling during his brief but fruitful career as Chief of the Service, and very much of the credit should go to him. Likewise, some of the lands acquired but not yet under administration and new refuges projected will become accomplishments of the future.

It takes more than building a dam or other water-control structure and flooding a piece of land to make a waterfowl refuge. Many things happen between the time the area is flooded and the date when the new marsh becomes capable of maximum production of waterfowl food and habitat. The development of the refuge system helped in the restoration that approximately quadrupled the continental waterfowl during the period between 1935 and 1944. Almost every area developed had been either completely de-

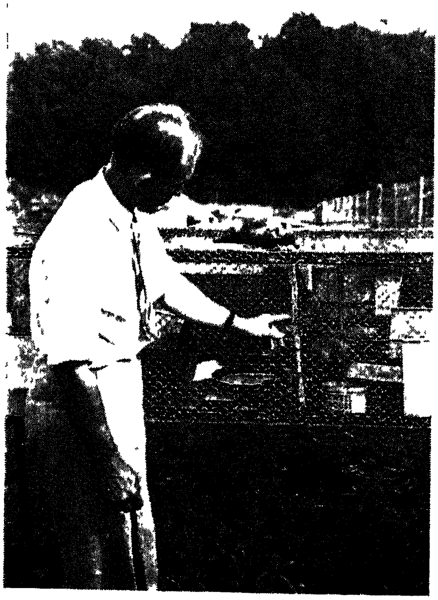


Photo by Wm. Schmidtman

EXPERIMENTAL ANIMALS

FERRETS KEPT ON PATUXENT RESEARCH REFUGE, MD.

stroyed by ill-advised drainage, or its production had so decreased that it was feasible to buy and restore it to productivity. In many cases the restored area represented the dream of one or more local conservationists. It is only necessary to mention Malheur Lake, Horricon Marsh, Lower Souris, Mud Lake, or the Montezuma Marshes to bring understanding to those acquainted with the lands.

One of the outstanding accompaniments to the refuge program was the development of successful techniques for harvesting, handling, storing, and planting seed and bulbs or other vegetative parts of waterfowl food plants. These methods are now routine practice, with a high percentage of success.

The physical development of these refuges, in retrospect, is a confused medley of building water controls and diversions that local wiseacres sometimes said could not possibly work but did; of building sand fences with the aid of the winds and the C.C.C. camps; of daring and ingenious applications of development schemes in a field where it was necessary to pioneer; of building fences and dikes; of planting aquatic plants and upland trees and shrubs; and doing the innumerable other things necessary to turn a piece of poor and largely nonproductive land into something of growing usefulness to the community and the nation. It took faith and long vision to undertake many of the projects, and the men in the Service had both in abundance.

Including the habitat available for waterfowl on refuges not tabulated as waterfowl refuges, it is probable that the total land dedicated to waterfowl usage on Federal refuges is approaching the halfway mark of the 7,500,000 acres originally outlined by Darling in his conception of the minimum needs of waterfowl. Developments during the past two years, including the quick drop of migratory waterfowl populations with additional shooting pressure and less favorable breeding seasons, emphasize the need for making available additional marshland to provide food and cover over more widely dispersed areas than now exist if the waterfowl resource is to be managed wisely.

Better cooperation between state and Federal conservation agencies. Again it is possible to report real achievement. Nine cooperative Wildlife Research Units, involving the four-way cooperation of the state conservation departments and agricultural colleges of the states in which they are located, the American Wildlife Institute, and the present Fish and Wildlife Service, were established in 1936. Later an additional unit was added. These Units are doing better work than ever, although their programs were sadly disrupted during the war period. They were originally set up as cooperative research and demonstration programs. The research could be either short- or long-time projects, and definite efforts were to be made to put the findings into use on the land by developing demonstration areas. Around these Units

Photo by Wm. Schmidtman

LAKE CONSTRUCTED BY C.C C., PATUXENT RESEARCH REFUGE, MD.

there quickly developed a program of undergraduate work in some of the schools, and all of them did work in training technical personnel. Whatever the value placed on the fact-finding and educational work accomplished, it is my opinion that the greatest contribution has been the development of five or six hundred well-trained young men who are now working in the wildlife field with a lifetime of productive effort still before them. From the beginning of this program the Service made definite efforts to help state conservation departments. The number of cooperative surveys and studies carried on with various game departments on specific problems of immediate concern to them has been great. Exchange of information between Federal and state technicians is now a common practice. Many states regularly detail men to the Patuxent Wildlife Research Refuge to use the facilities there and to have the benefit of working with other men in the same field. Since this was one of the hopes when Patuxent was visualized, it is very gratifying to see it develop.

The Pittman-Robertson Act, passed, and signed by the President, on September 2, 1937, was the greatest single wildlife conservation measure passed in the period under review. In outlining the program it was suggested that Federal-aid legislation on a basis similar to that of the Highway Aid Act was a necessary part of a sound conservation program. The act passed was much more comprehensive than the one visualized at the time the suggestion was made. It authorized three types of projects: purchase of land, development of land, and research that would improve the efficiency of wildlife administration in the state.

Although the war came on just as this program was well started, its accomplishments indicate that it is sound. All states except Nevada have qualified under the terms of the act. In the Western states programs have stressed big-game problems. Many of their land purchases have been made to secure winter range for troublesome big-game herds. Many Western states have also developed good small-game and waterfowl proj-

ects. The first project after the Pittman-Robertson Bill became a law and funds were available was a marsh development in the state of Utah. Midwestern and Lake states have devoted their funds largely to work with quail, pheasants, and rabbits. In several states the funds have been used to purchase small scattered areas for building ideal habitat for farm game. Others have leased these areas and developed the habitat. In the South the major emphasis has been on quail, with wild turkeys and deer receiving some attention, and the mourning doves becoming a major project in one or two states. In the Northeastern states deer, ruff grouse, and pheasants have had more consideration. Waterfowl projects have been scattered throughout the country. State men are finding that a combination of waterfowl and upland game projects, where possible, are convincing demonstrations to the public of the value of wildlife restoration. The construction of a lake or the restoration of a lake or marsh is a spectacular local event. When it is flooded and the waterfowl commence to use it, everyone can see it. An equally good job of restoring habitat for upland game and any game increase are much less noticeable to the public.

The lands acquired under this program already provide a substantial additional area primarily for wildlife use. As the years pass these state-owned and -managed wildlife lands will grow in relative importance.

There was one element of the proposed cooperation between state and Federal wildlife agencies on which little progress has been made. This was a cooperative educational program comparable to the present forest extension program So far no authorizing act has been passed by Congress. This does not mean the educational effort has been neglected, but it has been largely part-time work by men occupied with other assignments. The Fish and Wildlife Service is now authorized to cooperate in almost any way with state wildlife agencies. However, unless men having the special training necessary to translate the results of research into terms that landowners can understand are available, the job cannot be done effectively.

Closer coordination of Federal activities. In outlining this need it was stated that little difficulty was experienced in securing coop-

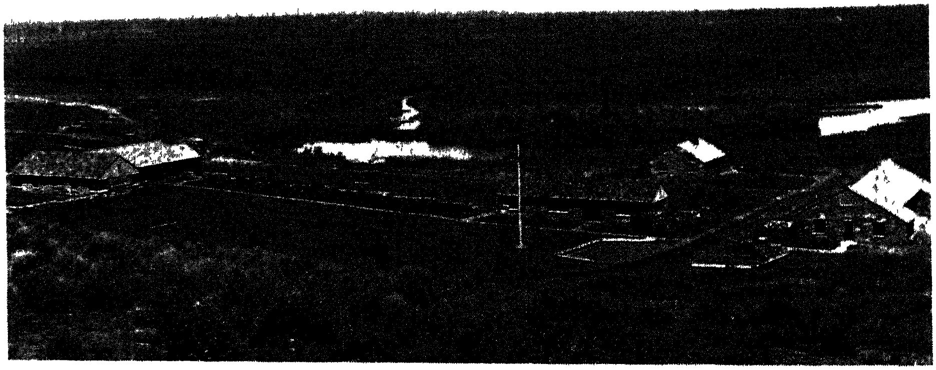
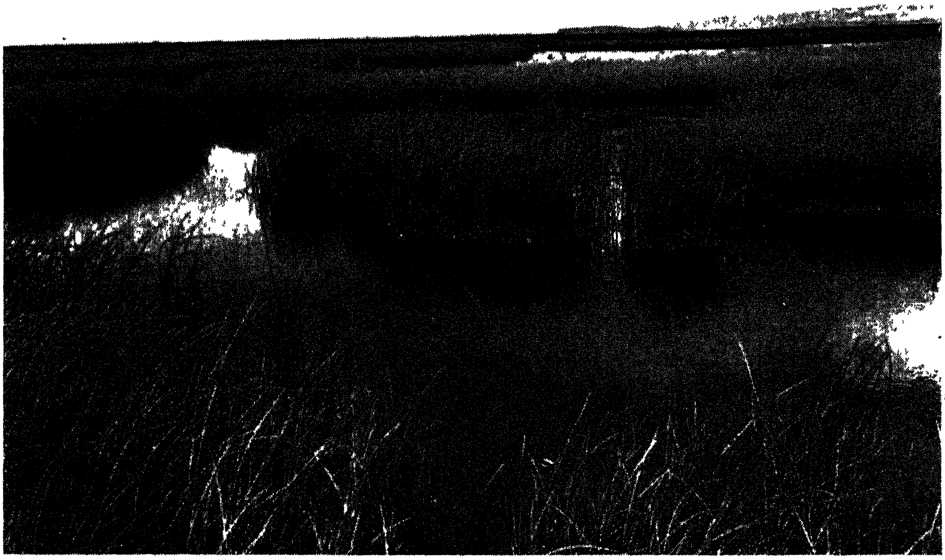


Photo by H. H. T. Jackson

HEADQUARTERS BUILDINGS, MALHEUR NATIONAL WILDLIFE REFUGE, ORE.



MARSH AREAS OF LAKE MALHEUR BIRD REFUGE, ORE.

BULRUSHES AFFORD FOOD AND COVER FOR MANY SPECIES OF WILDLIFE

eration between the major conservation organizations. The real need for coordination was between conservation and other Federal agencies whose activities often vitally affected conservation programs. Such organizations as the Army Engineers, the Reclamation Service, and the Public Health Service, in its mosquito control operations, were those particularly in mind. In the beginning, there was much difference of opinion over the necessity for marsh drainage for mosquito control, and more over the methods used. As a result of cooperative research there has been definite improvement; mosquito control methods much less destructive to wildlife have been developed. These better methods are not yet used by all local agencies, but there is less destructive activity in the marshlands.

The coordination act passed in 1934 provided an opportunity for the Fish and Wildlife Service to cooperate with Federal agencies developing flood control, hydroelectric reclamation, irrigation, and navigation projects. Cooperation was largely voluntary, however, on the part of the agencies concerned. There was no feasible method for either the Bureau of Fisheries or the Biological Survey to make their voices heard effectively unless the man in charge of a particular project was interested in conservation problems. Consequently, plans were often completed and construction under way before any consideration was given to the fish and wildlife problems caused by a project. By constant effort the Fish and Wildlife Service became so much of a nuisance by 1944 that better voluntary cooperation was forthcoming from the agencies working in water impoundments By 1945 the Service was receiving complete cooperation. It now has the opportunity to see preliminary plans of both the Army Engineers and the Reclamation Service and is often able to make field surveys on funds furnished by these agencies.

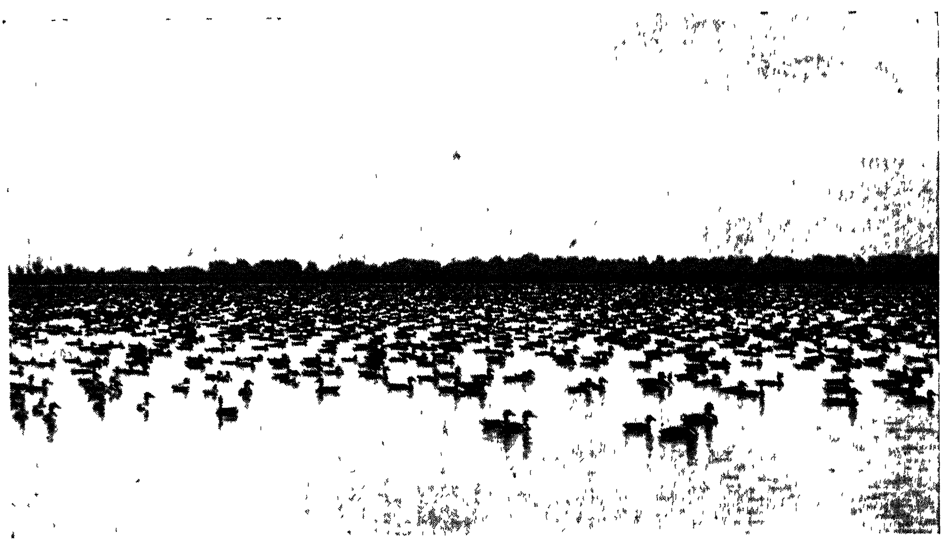


Photo by P J. Van Huizen

DUCKS AT "THE HOLE," SACRAMENTO NATIONAL WILDLIFE REFUGE, CALIF.

In July 1946 a new coordination bill, the Robertson Bill, wrote into law the cooperative practices now being followed between the Federal agencies. This act also gave the state conservation departments an opportunity to have their staffs work on these projects. This law does not and should not give to either state or Federal conservation agencies veto power over any project. It does give the right to protest any project as vigorously as desired. Reports and recommendations of the agencies go to Congress with those of the engineers at the time the appropriations are requested. At least Congress will have before it the effects of the proposed development on fisheries and wildlife as well as the usual engineering reports on the benefits to be derived from such developments. Because of this law closer coordination of Federal activities has been achieved both in practice and in terms of legislation. Perhaps success has come here to a greater degree than in any other objective.

Recognition of wildlife interests by public and private land-management agencies. National forests and the public grazing lands are the most important public lands from a wildlife standpoint. The national forests hold much of our remaining big game and provide a large share of the most valuable trout waters. The grazing lands are important to antelope, sage hens, and many of the Western quail. The Taylor Grazing Act and the formation of the Grazing Service made it possible to administer this land for the purpose of restoring badly overgrazed lands. Several states have worked with the grazing associations and the Grazing Service to develop better distribution of water for both wildlife and livestock. Springs have been developed and fenced, and water piped into troughs outside the fence. The stock do not trample the waterhole; the wildlife, particularly birds, get the benefit of the additional cover inside the fence; and both benefit by the additional water provided.

The National Forest Service has for years been conscious of forest wildlife values. Perhaps more than any other agency administering lands primarily for other purposes, it has tried to make provision for wildlife. As a result much big game and many small wildlife forms have greatly increased on the national forests. Many other state and national land-administering agencies are following these examples to some degree.

Progress has been made in interesting public land-administering agencies, but the effort to interest private landowners in the values of wildlife has been less successful. The establishment and development of the Soil Conservation District Program has been responsible for such progress as has been made. The Soil Conservation Service has been vitally interested in restoring to permanent vegetation badly eroded lands and other types unfit for farming Wherever plants useful to wildlife were available, they have been used in the permanent vegetative program. A great opportunity is now at hand for developing wildlife practices in organized Soil Conservation Districts, and perhaps progress may be greater in the next ten years.

Pollution control. For a time during the thirties real progress was made in pollution control. Hundreds of sewage treatment plants were installed, and pollution was decreasing in numerous areas. Construction of sewage disposal plants was slowed down or stopped entirely during the war. Many new industrial plants using new chemicals that produced new pollutants were built, resulting in the pollution of many previously undefiled streams.

One of the serious handicaps to a better control of pollution from a fish and wildlife standpoint has been the fact that there were no standards by which pollution from a biological viewpoint could be judged. The tests used were based on public health requirements. Many industrial wastes, relatively unobjectionable from a public health standpoint, are exceedingly destructive to aquatic life. Both fisheries and wildlife values are involved, since pollutants that destroy the smaller aquatic forms of life or kill the aquatic vegetation may affect both groups, although they may not kill fish or wildlife directly.

The Bureau of Fisheries had been working for years on these problems. With the appearance of new pollutants from war industries, additional funds were given the Serv-

Photo by P. J. Van Huizen

PINTAILS AND MALLARDS, SACRAMENTO NATIONAL WILDLIFE REFUGE, CALIF.

ice. Traveling laboratories were built and assigned for experimental testing of the effects of new chemicals and their waste products upon aquatic life. One consequence has been the publication by the Fish and Wildlife Service of a bulletin entitled *The Determination of Water Quality.* For the first time definitions and tests are provided that can be used for determining when pollutants of certain types are present in a degree harmful to wildlife. Corrective measures are also outlined as far as possible, although complete methods are not known for treating all industrial wastes. Even though the total amount of pollution may have increased, there is now better and more usable knowledge with which to combat it.

Wildlife research program. Here again progress can be reported. Despite the war and the interruptions caused in the work, much valuable new information is available. Discussing first the work of the Service itself, it can be said that research appropriations now are greater than in 1936. These are difficult to estimate accurately because wildlife research is carried on both by direct appropriations and by projects paid for by cooperating agencies.

One of the main values of a research unit lies in having highly trained technicians able to devise techniques and methods for solving new problems. The Service has been able to use these men in investigations of immediate problems not once but many times.

Perhaps the major physical advance has been the acquisition and development of the Patuxent Wildlife Research Refuge near Bowie, Md. Lying only 20 miles from Washington, this 2,600-acre tract of land, with adequate laboratories, is the first National Wildlife Research Station. For the first time research personnel had available buildings designed for research purposes and equipped with proper apparatus. Along with the development of this station, substations have been developed at the Bear River Marshes and at the Wichita Wildlife Refuge in Oklahoma. Small field laboratories, with facilities

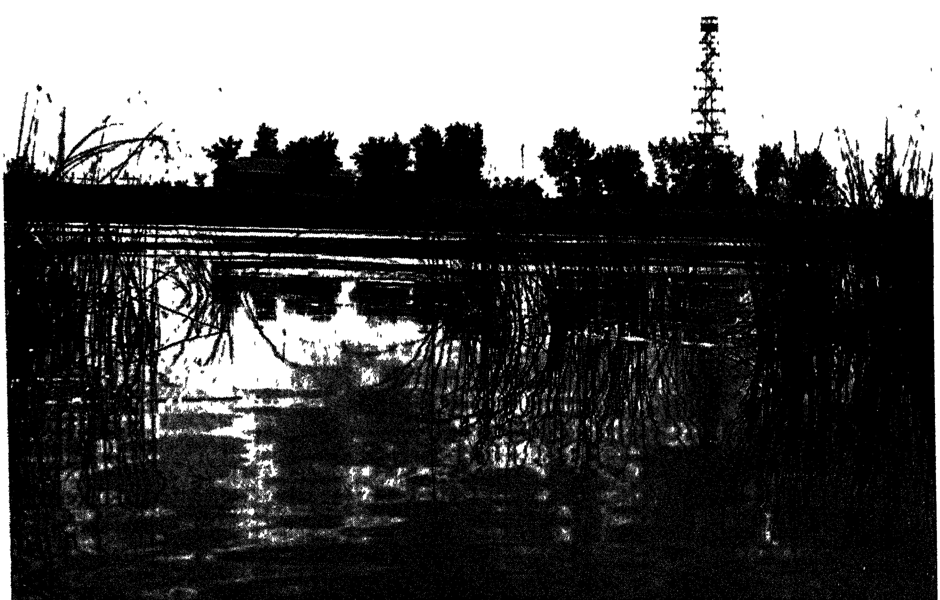


Photo by C. J. Henry

LOWER SOURIS (N.D.) HEADQUARTERS FROM THE MARSH

Photo by Greenwalt

ANTELOPE ON THE CHARLES SHELDON ANTELOPE REFUGE, NEV.

for preserving and handling material gathered in field studies, have been provided at most of the major refuges.

The Patuxent Station has undertaken long-time studies secure in the knowledge that these lands are permanently available. There should be a great increase in the basic research work as a result of these increased facilities. It would be difficult to pick out the outstanding research results or even to list the principal accomplishments in a short article. Among them, however, are the development of better methods of propagating and handling valuable aquatic plants, better methods of controlling such pests as saw grass and water chestnut, and the accumulation of knowledge of better methods of marsh management. Other outstanding research achievements in recent years have been the cooperative investigations with various mosquito control organizations, which have resulted in less damage to wildlife; the improvement of the annual surveys of waterfowl conditions and populations; the work on mourning doves at the Alabama Cooperative Unit, which furnished information on which administrative action curtailing September shooting was based; the white-winged dove studies, which resulted in definite management programs of cooperation by the Service and the states involved; and the studies on the Attwater prairie chicken in Texas, which resulted in a complete closure of the season by the Texas conservation authorities. Many studies on the facts that determine the success or failure of conservation of upland game, waterfowl, and fur-bearing animals in various sections of the country have been furnished, and definite techniques developed, to help in the better management of the various species of wildlife involved.

One of the most interesting and practical developments came from the continued study of botulism, which has resulted in methods of preventing or controlling outbreaks of this disease that are applicable to many areas. Another series of studies has

provided methods of using fire in marsh management. Fire can be used to control undesirable vegetation under certain conditions, the time and method of burning having much to do with success or failure. Many experiments have been made to determine the effects of variation of water levels on different types of plants, both noxious and desirable. The practical management of the marshes where water levels can be controlled or manipulated is now more certain and much less costly.

Considerable progress can be reported in developing new means of securing better forest reproduction in areas where destruction of seeds or seedlings by birds or mammals has been serious. New and more specific methods of control of destructive mammals have been developed and tested, one of the most interesting being the discovery that birds discriminate against certain colors and that ground squirrels and prairie dogs do not. Coloring of grains used in poison baits has provided an additional safeguard for valuable birds. It is impossible to enumerate all the various projects in which progress has been made. Rather, I have endeavored to mention some of the various types of studies that have produced results.

Laws and regulations for protection of wildlife. No wildlife management program can be successful without provisions for managing the harvest. Regulations governing the taking of birds and animals should be formulated upon the needs and condition of the wildlife population rather than upon the desires of those who take it. The Service, in recommending the waterfowl regulations and those for both fisheries and game in Alaska, endeavored to follow this basic principle. This has not been completely successful, but partly, at least, as a result of these efforts the public more willingly accepts the ideal as a goal toward which both state and Federal conservation agencies should work. Real progress has been made in advancing this concept. Many state game departments are now operating under laws that give them authority to make regulations based upon the wildlife conditions that prevail each year. In a growing number of states such programs are being carried on more or less successfully. They have often been handicapped by lack of trained men, a handicap slowly being overcome as trained men return from the armed services and new men begin to come from the schools.

The Fish and Wildlife Service's efforts to secure an adequate staff to enforce the waterfowl regulations have not been successful. Although the appropriation for this purpose has increased in the past ten years, it has not been sufficient to enable the Service to cope with the tremendous increase in the number of waterfowl hunters. Lack of adequate law-enforcement staffs is still one of the great weaknesses of the Fish and Wildlife Service, and the same is true of many state game departments. In some states funds are sufficient to maintain an ample staff, but state pay scales, restrictive employment laws, or political handling of employment make it impossible to hire competent men. Even the states that have the best enforcement records do not have adequate staffs to control the growing number of violations. Law observance is still a major need if the wildlife resources of the country are to be intelligently managed.

FISHERIES PROGRAM

It is not so easy to outline the progress made in the fisheries program, since my close contact with it goes back only to July 1, 1940. It is evident, in examining reports for the period 1936–40, that the program resulted in building and equipping new laboratories, in expanding research programs, in repairing and modernizing old hatcheries, and in building additional hatcheries.

Since neither the Bureau of Fisheries nor the present Fish and Wildlife Service have regulatory authority over the taking of the fish within the continental United States,

any improvement in the protection of existing fishery supplies has been made by the states. Contributions of the Federal group have been largely in research. For example, they have studied the effects of planting various-sized fish in the streams and waters of this country. In the eastern United States they found that planting small trout was useless in many streams. Federal hatcheries and some state hatcheries are planting fewer and larger fish as a result of these findings. Similar investigations in the Great Lakes in commercial and sport fisheries indicated that the depletion of many species was due to a combination of overfishing and inadequate law enforcement. This was confirmed by extensive hearings held by the Great Lakes Fishery Inquiry group established cooperatively by Canada and the United States. The studies and hearings resulted in the negotiation of a Great Lakes Fishery Treaty—a new departure in state, Federal, and international relationships. State governments were consulted freely in developing the treaty and are provided a voice in its administration to a greater extent than has previously occurred in any international convention. This treaty should be ratified promptly, since it provides machinery for regulation of the fishing in a lake or a section of a lake according to the existing biological conditions rather than regulation by state or international boundary lines. This treaty, if ratified and if suitable enabling legislation is passed, can not only prevent further deterioration of the fisheries but can gradually rebuild some of the former values.

The development of fishery resources in interior waters has been greatly accelerated by the farm pond program, an integral part of the soil erosion work of the Soil Conservation Service. Many thousands of farm ponds have been stocked by Federal and state hatcheries in a cooperative program, resulting in the development of thousands of new fish-producing areas.

At the same time the Federal fish hatcheries in interior states have devoted their major efforts to producing sport fish. In mountain areas trout have been the principal species, and bass, crappies, bream, and catfish have been the main species propagated and distributed in the valleys.

Since the formation of the Fish and Wildlife Service the hatcheries division has been reorganized and staffed with technicians so that the fish produced can be planted in suitable waters and have a maximum chance of survival. Coordinated programs with the states have made it possible to distribute fish at less cost and ensure that only fish suitable for the type of water are planted. This should lead to the maintenance of better stocks of fish and to better fishing.

Because of the heavy fishing pressure on the Eastern trout waters, it is not possible to meet the demand except by restocking several times a season. The tendency is to plant fewer and bigger fish, preferably those of legal size. Research studies showed this to be the most practical method of meeting the need.

Similar efforts are not needed with warm-water fish. Their rate of reproduction is greater, the food supplies in the warmer lowland waters are relatively more abundant, and the quantity of fish that may be produced greatly exceeds that of an equal area of trout water.

The reclamation of fishing waters was a project on which considerable progress had been made by reducing pollution in many streams. The war not only stopped construction of many sewage reduction and industrial waste treatment plants but brought a great many new war plants into existence. Many of these used new chemicals and poured into the streams new pollutants whose effects were not known. As a result there are now probably more waters polluted than ever, since many of these plants poured their effluents into hitherto unpolluted water

Pollution is a major postwar problem that must be attacked with renewed vigor. Fed-

eral legislation is needed to get at those cases of pollution where action by one state will not suffice to clean up a stream. These cases may fall into two categories: where the streams form a common border of two or more states; where a stream rising in one state may be polluted as it enters a second state even though the latter makes every effort to keep the waters clean.

Although the fisheries research staff had accomplished much, there was no group in the Service whose work was more handicapped by the war. Many men were called for war duty in the Office of the Coordinator of Fisheries, in other civilian war agencies, and in the armed forces. This represents a permanent setback in time for much of the basic program In addition, for the first time in many years it had been possible to get oceanic research boats under construction. One, furnished by the fishing interests of the North Atlantic, was being equipped for offshore research work. This boat was taken by the Navy, altered for naval use, and will now require other alterations before it can be used or research purposes. A second research vessel was on its way to Alaska for fur seal work. It had been completed, equipped, and staffed with biologists and a crew when the Navy took it. That boat is again available, stripped of most of the equipment with which it had been fitted; a major job of overhaul will be necessary before it can be used. The fact that these boats are still not usable after five years represents a distinct loss in securing basic data to meet conservation problems in the two areas

The completion of the Little Port Walter Pink Salmon Station in southeastern Alaska was another forward step. This station, built with weirs to count adult fish in and fry out of the stream, is the first available to the Service. It operated during the war period and has already furnished invaluable information regarding the expected runs of fish. The value of the station will grow as basic data accumulate, but several substations scattered throughout the southeastern Alaskan pink-salmon area are needed before an adequate job can be done.

It is not possible to mention all studies that have led to definite management recommendations. As a result of studies of the lobster populations, Service biologists recommended an increase in the minimum legal size limit for taking lobsters. This limit was adopted by the major lobster-producing states some years ago. Its adoption and enforcement have been accompanied by a great increase in the lobster catch, and it is believed that some of this increase is a direct result of the recommendations.

Similar investigations of the striped-bass population of the North Atlantic resulted in a recommendation of a minimum length of 16 inches. Many states have already enacted the legislation recommended, although two of the most important, Virginia and Maryland, have not. They have raised the minimum size limit somewhat, but still not enough to ensure the escapement of adequate spawning stock.

Shad studies carried out in various rivers resulted in recommendations that a greater escapement of shad to the spawning grounds be allowed. In the Hudson River, as a result of a management program, the shad catch has increased from something like 40,000 pounds a year to over 4,000,000 pounds. A spawning escapement of 50 percent of the adult fish occurs in this river, and 40–50 percent escapement of adult shad has been recommended for all shad streams. Few states have adopted this recommendation, although Maryland, under a new fisheries regulation, has been building toward an adequate escapement, with an increase already noticeable in both the shad population and the commercial catches.

Maryland has adopted a rather revolutionary fisheries law which freezes the number of commercial fishing licenses and provides for a gradual reduction in their number over the years. This law was based on a rec-

ommendation growing out of research on the Chesapeake Bay fisheries by Service biologists.

In the commercial fisheries field similar accomplishments have been achieved by the technological workers. There are now laboratories in Ketchikan, Alaska; Mayaguez, Puerto Rico; College Park, Md.; and Seattle, Wash. In addition, two traveling laboratories are in use on the Atlantic coast This group did pioneer work on the king crab in the Bering Sea. As a result, a number of commercial organizations are now engaged in experimental fishing for this crab Although formerly caught almost exclusively by the Japanese but sold largely in the American market, there is no real reason why American fishermen should not take, and American workmen process, these giant crabs.

Technological research work was greatly curtailed by the necessity of doing war emergency work. Despite these difficulties, work was continued on vitamin A. Much was done to find new sources of this vital commodity and to develop better methods of handling and sampling shark livers. In fact, a sampler developed by a Service research man is now widely used commercially. Much was also done to develop methods of processing fish that could not previously be successfully handled.

Few people appreciate the handicap under which the commercial fisheries operated during the war. At the outset the armed forces seized for auxiliary use some 700 of the largest, newest, and best fishing boats, thus reducing the efficiency of the fleet much more than the actual number taken would indicate. In addition to the shortage of manpower and supplies common to all industries, the fisheries quickly found themselves in direct competition with the Navy for marine motors and small-boat equipment and with the Army for twine for fishing nets. The industry managed, however, to hold production at almost normal level. Where there was a special need for certain products they even succeeded in increasing production. Many of the Service research workers became key men in meeting war problems. Their technological work was directed at immediate problems, and they often came through quickly with the solution. One way in which greater production was obtained was by developing methods of handling and marketing fish not previously utilized. Many of these fish will probably find some permanent place in American markets. This will make possible a constant supply of fish and at the same time a conservation program to build up any depleted fishery. The nation is slowly realizing that, although the bounty of the ocean seems inexhaustible, there is a limit to the number of pounds of any one fish that can be taken This limit may be imposed by the increasing cost of taking additional fish or by the biological conditions of the stock itself.

The clearest case of this kind has developed in the haddock and pollack fisheries on the Georges Bank off Cape Cod. Because of its nearness to markets this Bank has been overfished for years. Studies carried on by Service biologists have shown that the deciding factor is the removal of too many fish of less than 2.5 pounds. These fish are taken before they have passed their period of maximum growth and also before they have spawned. Exhaustive studies of these populations have shown that the number of fish can be increased by permitting the escapement of as many 2.5-pound fish as is possible by using larger-mesh nets. If such a program could be carried out, within five or six years this Bank would produce 100,000,000 pounds more fish annually. A voluntary program was undertaken, and results were beginning to become apparent when the war demand for food stimulated a greatly increased market for these immature fish. This means that unless some agency has authority to make and enforce the necessary regulations it will be difficult, if not impossible,

to develop a sound management program.

The Service has endeavored to carry out the principles of the 1936 statement in Alaska. It has tried to maintain the stocks and to obtain the widest possible utilization of the products of the fisheries. It has not been entirely successful. During the war years many of the personnel were lost from the Alaskan Service. This loss, coupled with the high price of fish and the pressing demand for canned salmon, has made it impossible to carry out an effective law-enforcement program. In several areas the salmon stocks are seriously depleted despite the most vigorous attempts at sound management. The reduction is most marked in the pink salmon in southeastern Alaska, but these somewhat erratic fish may be expected to recover more quickly under proper protection than the depleted runs of red salmon further to the west. Since red salmon run in four- or five-year cycles instead of two, it takes a much longer period of years to build up depleted runs.

The herring populations had been successfully rebuilt so that it was possible to greatly increase the take during the war as the results of several previous years of conservation became effective. Just prior to the war all herring fishing was stopped in southeastern Alaska for several seasons, and greatly reduced quotas were allowed in Prince William Sound and the Kodiak area. After several fairly successful spawning years, the herring became much more abundant in 1943–45, when fish oil was most needed.

The very successful program of the International Fisheries Commission in building up the halibut population from the low point reached about 1930 also made it possible to permit an increased take each year without interfering with the valuable rebuilding program.

IN RETROSPECT, I find that my years at the head of a conservation organization were exciting ones. In general I believe they were years of real advances, especially prior to our involvement in the great war. From 1935 to 1941, there were tangible accomplishments and there was much that is permanent. The war years were spent largely in protecting the gains made during the more constructive times and in handling the many war problems that came in the wildlife and fisheries field. It is my belief that the wise use and careful management of our natural resources, including wildlife, is now more than ever a national necessity. It is increasingly important that we do a better job in view of the increasing demands on all resources. This will be difficult to do, particularly in the face of the "economy program." I am sure of one thing, and that is that the personnel of the Fish and Wildlife Service and other conservation agencies will do their best to accomplish that objective regardless of all obstacles.

THAT MORE PEOPLE MAY LIVE BETTER

By CHARLES MORROW WILSON

Mr. Wilson (B A., University of Arkansas, 1926) is a journalist who specializes in reporting and appraising tropical countries In December 1946 he returned from a trip to Equatorial Africa—a trip he described as "a magnificent adventure." He had previously visited and worked in Liberia during 1945 Mr. Wilson is a director of the American Foundation for Tropical Medicine. In June of this year he received the official citation of distinguished alumnus from his alma mater.

AMERICAN scientific interest in the tropics, as the perennial reservoir of raw materials and the home of almost half the human race, takes a new forward step with the establishment in Liberia of an international medical research center.

This institute is under the sponsorship and direction of the American Foundation for Tropical Medicine, Inc., the administrative affiliate of the American Academy and the American Society of Tropical Medicine and a nonprofit corporation with headquarters at 270 Madison Avenue, New York.

The research institute, which will be built and equipped during 1947–48, is to be located in Liberia, the only African republic, at a point about three miles from Roberts Field, the major land air base of West Africa. Its site is near the Farmington River, a few miles inland from the port of Marshall, and about 50 miles upcountry from Monrovia, the Liberian capital.

Harvey S. Firestone, Jr. has granted $250,000 to the Foundation for use in constructing the primary buildings and purchasing basic equipment for the institute. The Republic of Liberia, by authority of its president, William V. S. Tubman, has donated 100 acres of highly desirable land as a site for the research center and has granted an option for an additional square mile of land which the institute may develop as a livestock range.

The American Foundation for Tropical Medicine, whose membership and directorate include prominent businessmen as well as leaders in the various fields of tropical medicine, is under contract with the Liberian government to maintain and supervise the research institute for a period of five years, and to direct and assign research projects with the assistance of a qualified resident director and staff, to appoint personnel, to disseminate findings to interested scientists of any nation, and to grant research fellowships to deserving scientists without restrictions as to race, creed, or color.

The scientific advisory committee for the Liberian Institute consists of the following representatives of participating institutions, which are members of the American Foundation for Tropical Medicine:

Dr. Herbert C. Clark, Director, Gorgas Memorial Institute (Panama)
Dr. Hamilton H. Anderson, California
Dr. Rodney Beard, Stanford
Dr. George C. Shattuck, Harvard
Dr. James S. Simmons, Harvard
Dr. Malcolm Soule, Michigan
Dr. William Taliaferro, Chicago
Dr. Carroll E. Roach, Director, Eli Lilly and Company Research Laboratories
Dr. Edward I. Salisbury, Medical Director, United Fruit Company
Dr. James A. Shannon, Director, The Squibb Institute for Medical Research
Dr. Donald S. Martin, Duke
Dr. Henry E. Meleney, New York University
Dr. Thomas T. Mackie, Bowman Gray School of Medicine (President of the American Foundation for Tropical Medicine)
Dr. Perrin H. Long, Johns Hopkins
Dr. Justus B. Rice, Winthrop Chemical Company

Dr Joseph L. Johnson, Howard
Dr E Carroll Faust, Tulane
Dr James N. De Lamater, Southern California
Dr Jean A. Curran, Long Island Medical College
Dr Sterling Brackett, Director, American Cyanamid Research Laboratories
Brigadier General George R Callender, Army Medical College
Dr Harold W Brown, Columbia
Brigadier General Raymond A. Kelser, University of Pennsylvania

The Liberian Institute is launched as a major enterprise of the Foundation, whose current work program includes the sponsoring of medical school courses in tropical medicine; extensive grants to the Tulane School of Medicine (which now maintains the only graduate department of tropical medicine available within the United States); granting of fellowships at Tulane for talented graduates of Latin-American medical schools; also grants-in-aid for the publication of noteworthy critiques and reports in the field of tropical medicine, including partial support of such scientific periodicals as the *Journal of Parasitology* and *The American Journal of Tropical Medicine.*

As the major project of the Foundation, the Liberian Institute will stress international cooperation in tropical study. Dr. Thomas T. Mackie, who is President of both the Liberian Institute Corporation and the American Foundation for Tropical Medicine, Inc., is receiving assurances of cooperation from the schools or departments of tropical medicine of London and Liverpool Universities, the Hamburg Institute; the Swiss government medical academy; the Belgian government; the Riff Valley Institute, of the Belgian Congo; the Louis Pasteur Institute, of Paris, which maintains African field stations in Algeria, Tunisia, and at Dakar, and the Liverpool School of Tropical Medicine's renowned West African field station located in the British colony of Sierra Leone. In addition, many government and military medical services, including the Medical Corps of the U. S.

NATIVE VILLAGE NEAR HARBEL, LIBERIA

TYPICAL LIBERIAN COUNTRYSIDE

NEAR THE NEW LIBERIAN INSTITUTE FOR RESEARCH IN TROPICAL MEDICINE.

Army and Navy, and the U. S. Public Health Service, have expressed interest and willingness to cooperate in the research projects planned or contemplated for the new Liberian center.

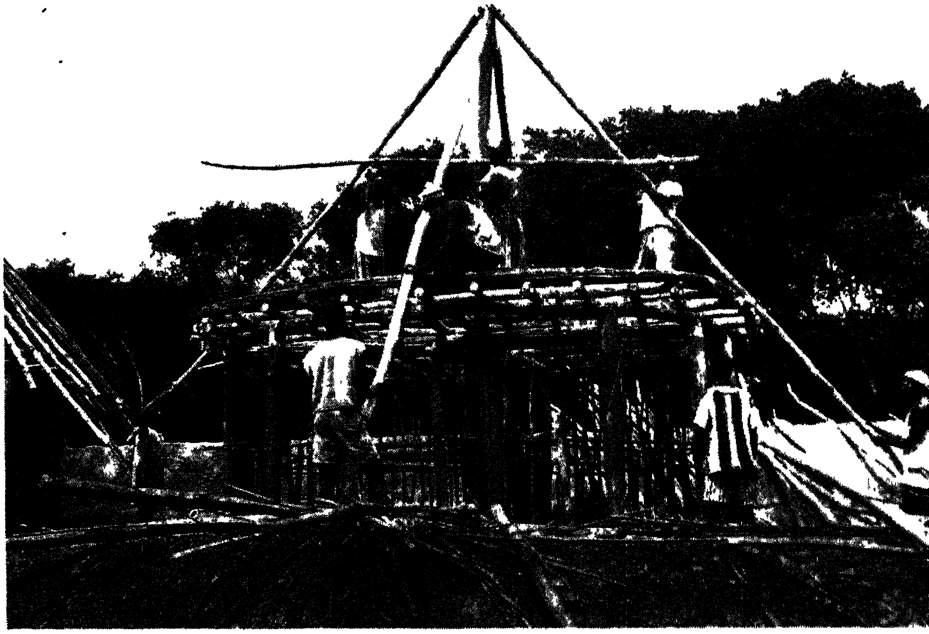
Surgeon General Thomas Parran, of the U. S. Public Health Service, recently stated in a letter to Dr. Mackie:

> ... In my opinion no single effort in this field [of tropical medicine] is more worthy of whole-hearted support .. When we consider the fact that just one tropical disease—malaria—constitutes the number one world health problem, we know there still is a big job to do in this sector. When we further realize that distant points no longer exist in the world—that this indeed is one world—we also know that it can be a world of disease or a world of health, depending upon how vigilantly we in medicine work for freedom from disease....

The executive committee of the Liberian Institute announces that all reasonable efforts will be made to make the Liberian Institute available, even during its earlier stages, as a hospitable working headquarters for qualified scientists previously or otherwise interested in carrying on independent research in fields related to health and nutrition in the tropics.

The resident staff will consist of a director, assistant director, and a skeleton research staff, which will probably include a chemist, pathologist, parasitologist, pharmacologist, and other members as required. The staff will thereafter be supplemented by grants of fellowships and exchanges as directed by the scientific and medical advisers of the American Foundation for Tropical Medicine.

The institute's projects will include research and experimentation with regard to



AFRICAN-STYLE HOUSE-RAISING

the feeding, husbandry, and pathology of tropical livestock, particularly poultry, cattle, and work animals. The Foundation is convinced that improvement of animal husbandry in tropical countries is a salient requirement for adequate human nutrition in practically all tropical countries. The chronic lack or insufficiency of beef, milk and other dairy products, fowls, and eggs accounts for the common inadequacy of protein foods in tropical diets. This has long been a primary concern of tropical medicine. Also, the possibilities for improving livestock resources in tropical countries are otherwise basic to the development and well-being of those countries. For example, healthy draft animals are required for supplying the power necessary for realizing the vast potential productiveness of tropical soils. In hot-weather countries with heavy rainfall, animal manures are particularly valuable for replenishing and perpetuating soil fertility. Furthermore, many of the domestic animals, if sickly, serve as reservoirs or hosts to serious human maladies or in other ways facilitate the spreading of disease among peoples. It is also true, as in the instance of certain types of malaria and trypanosomiasis, or African sleeping sickness, that common domestic animals suffer from types of disease organisms similar to, and in some instances actively related to, organisms that cause human diseases.

Numerous medical authorities agree that Liberia, located in the highly verdant rainforest belt of West Coast Africa, at a latitude ranging from 4° to 7° north, is an excellent vantage point for such a research center. The area has long been an endemic center for malaria, sleeping sickness, and many other parasitic diseases; also for yaws and other spirochete diseases; numerous

dysenteries, some of which are not yet classified; tuberculosis, filarias, including elephantiasis and schistosomiasis; and many virus diseases. The institute's site is well-drained agricultural land, accessible to highways, power lines, and a radio telegraph station, and near to varied and typical tropical terrains, including swamps, river valleys, and hilly lands.

As the only republic and one of the two sovereign nations of present-day Africa, Liberia has assured the ready admission of holders of accredited medical licenses from all nations and all other bona fide scientific workers. The Liberian people, numbering about 1,600,000 and for the most part members of 21 indigenous tribes, are respected as one of the most cooperative and peace-abiding of publics. In its hundred years of sovereignty Liberia has never had a revolution, suffered a major civil war, or by-passed a lawful election. In terms of credit and debt status, as well as law enforcement, the Negro republic has earned the respect of all nations.

The Liberian Institute is being, and will be, supported by grants and contributions from American industries and business and educational establishments interested in the development of tropical trade and the specific improvement of international relations. Thus far most of the commercial firms that contribute to the institute are either drug and pharmaceutical houses (which recognize that the Liberian Institute will provide a strategic center for the practical testing of new agents and drugs, as well as established pharmaceutical products) or major concerns such as United Fruit Company and Firestone Tire and Rubber

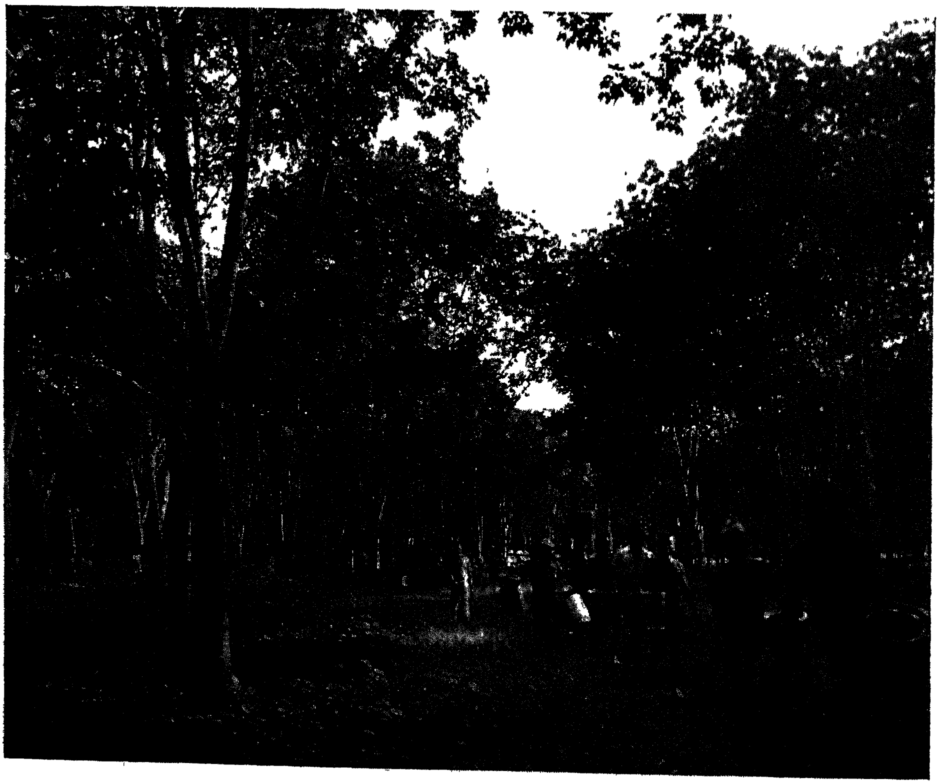
TYPICAL FARM HOME IN LIBERIA

Company, which operate extensive properties in the tropics.

At present the American Foundation for Tropical Medicine is seeking to broaden the bases of sponsor interest on the grounds that tropical medicine is essentially international medicine. Relatively few of the so-called tropical diseases are confined to the tropics. The great majority, including malaria, the No. 1 communicable disease of the world today, leprosy, dysenteries, tuberculosis, and many others, are world-wide enemies which, like almost innumerable species of plants and animals, have taken refuge in tropical lands whose climates and environments tend to minimize the risks of survival.

It follows that in the world of today, in which there no longer exist truly distant places, wherein any habitable area is within 60 flight-hours of any other habitable area, diseases in the tropics actively menace the health and economy of all peoples without regard to locale or latitude. Nowadays, indeed, any one of us can contract a disease in the tropics, return home by plane, and go to our work for several days or weeks before actually "taking down" with the disease. And, ironically, as the medical section of the United Nations has recently pointed out, present-day facilities and technologies for quarantine are gravely inadequate to meet the prevailing needs of the global war for human health.

The importance of tropical medicine to world trade is likewise stressed by the Foundation in planning the new research center in Liberia. It is common knowledge that in the tropics or elsewhere unhealthy



LINE OF RUBBER TAPPERS, HARBEL, LIBERIA

people cannot work or produce effectively and therefore do not prosper. The truth is, too, that in tropical countries good health is not inherent, cannot be taken for granted, and as a rule can be maintained only by continuing, costly work supported by ceaseless research and improvement.

The leadership of the American Foundation for Tropical Medicine points out that United States trade with tropical countries grows impressively with each passing month despite the severe upset of labor, shipping, and other trade prerequisites in many or most major tropical areas. Though trade in many basic tropical commodities, such as natural rubber, bananas, and fiber crops, continues to show the derangement occasioned by World War II, it is today the greater part of our foreign trade.

Recent U. S. Department of Commerce records show that even during the present transition year the United States is importing all its supplies of the following commodities from tropical nations or colonies. Figures here quoted are for 1945, the latest tabulated totals. Significantly, because of irregularities and upheavals occasioned by the global war, 1945 was not a "good" year for tropical trade.

Products	Value
Coffee	$345,835,000
Cane sugar (imported) (6,573,758,000 lbs.)	?
Natural rubber (311,900,000 lbs.)	98,975,000
Crude petroleum (imported)	74,125,000
Diamonds	64,185,000
Cacao or cocoa	45,916,000
Edible nuts	39,706,000
Palm oils	34,264,000
Tea	29,497,000
Bananas	28,397,000
Molasses (industrial)	20,405,000
Rums and other spirits	19,160,000
Vegetable oils (edible)	15,948,000
Tin	9,163,000

In addition, the 1945 statistics show that the United States imported substantial or major portions of the following commodities from tropical countries:

Aluminum	$675,210,000
Copper	182,116,000
Nickel and alloy	42,814,000
Fertilizers	41,327,000
Industrial chemicals	37,894,000
Cotton manufactures	33,649,000
Vegetables	31,685,000
Lead	25,516,000
Cotton cloth	22,854,000
Plywoods	21,016,000
Leather manufactures	17,916,000

Current United States exports to tropical countries show the following major items: meat products and lard; industrial machinery (including machinery for mining, generating electric power, construction, and metal working); motor fuels and lubricants; iron and steel "semimanufactures;" autos and trucks; tobaccos; lumber; auto tires and other rubber manufactures; cotton goods; woolens; steel mill manufactures, electrical machinery and apparatus; radios; medical and pharmaceutical preparations; soaps and toilet goods; scientific and professional instruments; dairy products (other than fresh milk); dehydrated foods; coal-tar products; books, maps, and other printed matter.

Department of Commerce statistics indicate that at present more than half of all the foreign trade of the United States is with tropical areas, with exports of manufactures and imports of necessary raw materials predominant.

Official tabulation completed through 1945 shows that during that year of transition from war to peace the United States exported about 4.122 billion dollars' worth of goods to tropical countries or colonies and imported about 3.54 billion dollars from them, both totals exclusive of military supplies. During the same year the grand total of all United States exports and imports was slightly less than 14 billion dollars.

Significantly, United States trade with tropical lands has more than doubled since 1936 and is clearly headed upward. On a per capita basis our present exports to tropical areas are believed to total about $50 a year for every inhabitant of the United States. Despite unsettled world conditions the trade balances remain generally favorable to the United States.

For example, during 1945 our exports to Africa totaled $523,761,000 against imports of $295,859,000; our exports to Oceania and lower Asia totaled $1,199,000 against $576,271,000 in imports. During the same year United States exports of $645,491,000 to South America were overbalanced by imports of $962,428,000.

The most recent approved resume of United States trade with the tropics shows the following totals in thousands of dollars as of 1945, except as otherwise noted:

Country	Exports to the United States	Imports
Mexico	$1,262,928	$1,623,264
India and dependencies	491,251	173,157
Cuba	308,683	230,620
Brazil	215,617	311,250
Australia	310,649	125,981
Hawaii	240,815	87,460
Puerto Rico	160,969	144,675
Union of South Africa	131,120	103,830
Venezuela	136,720	86,665
Colombia	88,299	102,847
Egypt	164,810	11,234
Ceylon	86,096	67,013
Uruguay	48,606	66,145
Curaçao, N. W. I.	30,820	64,670
Algeria	91,544	2,022
Peru	42,521	33,591
New Zealand	37,303	33,738
Belgian Congo	17,787	48,657
Kenya-Uganda (1944)	27,200	22,500
Iran (Persia)	$28,106	$17,318
Bolivia	14,275	27,902
Guatemala	14,679	24,267
Panama	33,721	2,613
Dominican Republic	18,777	14,460
Ecuador	15,230	14,005
Costa Rica	16,023	10,916
Haiti	9,611	15,949
Iraq	10,960	10,461
Southern Rhodesia (Africa) (1944)	9,300	11,600
Honduras	10,262	9,020
Netherlands Indies	20,951	2,015
El Salvador	8,672	6,970
British Gold Coast (1944)	7,300	8,600
Nicaragua	8,531	5,024
Tanganyika	7,000	5,600
Paraguay	2,562	6,221
Virgin Islands	4,575	4,117
British Malaya	1,045	5,724
French Morocco (1944)	2,665	3,609
French West Africa (1944)	1,726	2,077
Mozambique (Africa) (1944)	1,627	1,813
Indo-China (1944)	865	650

On the basis of these statistics, and other reliable proof of the steadily growing importance of tropical trade, the American Foundation for Tropical Medicine seeks the support of business as well as science in perpetuating the international research center for tropical medicine. On the grounds that good health is a first essential to good business and secure lives, the Foundation submits that interdependence between the United States and the tropics is more vital than ever before in this age when living conditions abroad have become an essential factor of our lives at home.

PROGRESS IN THE TRANSFORMATION OF ENERGY*

By P. C. KEITH

Mr. Keith, as President of Hydrocarbon Research, Inc., is putting the final touches on a process for the conversion of natural gas to 90-octane gasoline. During the war he was a member of the Planning Board, S-1 Section, O.S.R.D., forerunner of the Manhattan District. Later, as Vice-president and Technical Director of the Kellex Corporation, he was responsible for all research and development, process design, engineering, procurement of materials, and supervision of plant construction for the Oak Ridge gas diffusion project.

BECAUSE so much has been written concerning our dwindling oil reserves by the National Resources Planning Board, the Department of the Interior, the O'Mahoney Committee, and members of the oil industry, most Americans are acutely conscious of what they believe to be an impending oil shortage. There seems to be a general feeling that this country must import additional supplies of petroleum to maintain and expand our present "internal combustion engine economy." Although there may be many reasons favoring the importation of petroleum, such importation is not necessary for our national security; and in the foreseeable future it might be undesirable both for security and economic reasons.

In the past two decades enormous strides have been made in the production of synthetic fuels from both coal and gas. In 1910 Bergius announced his high-pressure process. In 1927 I. G. Farben built at Leuna the first commercial plant. In the late twenties Franz Fischer announced the low-pressure Fischer-Tropsch process. In 1934 Ruhr-Chemie installed the first commercial plant at Oberhausen. Beginning in 1939 the mechanized German army, fueled primarily by the 100,000 barrels per day of synthetic oil produced from coal by these two processes, fought and nearly won a war.

It is certainly true that the cost of these synthetic oils was much higher than the cost of those produced from petroleum. On the other hand, in the light of present-day American engineering knowledge, the processes used were clumsy and unnecessarily expensive.

The production of oil from natural gas is closely akin to the production of oil from coal. Recently two companies, Carthage Hydrocol, Inc. (a company composed of various units within the oil industry), and the Standard Oil Company of Indiana, have announced plans for building two large commercial synthetic oil plants, utilizing dry natural gas as the feed stock. Both these companies expect that the cost of the motor fuel produced will be at least competitive with the cost of motor fuel produced from crude oil. The prediction has been made that the cost of motor fuel from one of these plants will be 5.25 cents per gallon. Capital charges represent about 50 percent, and raw materials about 20 percent, of this cost. When these plants have a successful performance record behind them, thus allowing a reduction in the capital charges of future plants, the raw-material cost could double or treble and the cost of fuel made would still be competitive with the cost of fuel made from crude oil.

Mr. H. C. Weiss, President of the Humble Oil and Refining Co., has announced in the press that his company is considering the installation of a gas synthesis plant. This process can convert our gas reserves into an amount of oil equivalent to our known

* From a paper presented at a symposium on "Progress in the Transformation of Energy" at the Princeton University Bicentennial Conference on Engineering and Human Affairs, October 2–4, 1946.

reserves. The possibility of quickly and economically doubling our oil supplies should be given great weight in predicting future national economy. In discussing the "over-all significance of the process,"

Mr. Weiss placed particular emphasis upon natural gas because of the importance of the future oil supply of the United States being at home or near home to insure national security in emergencies as well as the assurance of adequate peacetime supplies. Middle East oil, he suggested, would be too far out on the supply lines to be of use in the lightning war of the future.

The engineering knowledge responsible for this advance in the synthesis of oil was acquired in America during the war. Two new techniques were outstanding: the use of the "fluid bed" and the production of cheap chemical oxygen. Both these techniques can be applied to the synthesis of oil from coal. Before the O'Mahoney Committee in 1943, testimony was presented which showed that oil could be made from coal, using the high-pressure hydrogenation process, at a cost of from 16 to 18 cents per gallon—a cost so high as to be of no immediate interest to our oil industry. Recently a major oil company, familiar with hydrogenation, has privately informed me that it now believes that with a "mine-mouth" coal cost of $2.50 per ton motor fuel could be produced for between 7 and 10 cents per gallon, all costs in. My own figures indicate a possible cost of 6.5 cents per gallon, all costs in, with coal at the mine mouth worth $2.00 per ton. This latter figure is competitive with the cost of motor fuel produced from present-day crude oil. When this coal-to-oil development has been brought to a successful conclusion—and I use the word "when" rather than "if"—an important milestone in the transformation of energy will have been passed. The gas-to-oil conversion process has already materially increased our potential oil supplies, but the coal-to-oil process will cause us to reckon our future supplies by the hundreds of years rather than by decades. At that time the cry of "our dwindling oil reserves" will be heard no more. A large segment of the oil industry already believes that the economic equivalence of gas to oil has been proved, and that the economic equivalence of coal to oil will be proved in a few years. I believe that present technological developments ensure that in the future we shall have a cheap and abundant domestic supply of oil for use in aircraft, automobiles, locomotives, house-heating systems, etc.

Concurrent with advances made in the synthesis of oil from coal and gas, there have been extremely important advances made in the conversion of coal into gas. The Lurgi Company, of Germany, in 1936 placed in operation at Zittau their first high-pressure coal gasification plant to produce directly from coal (i.e., without using any oil gas for enrichment), a gas suitable for town use. The process is simplicity itself. By means of a lock-hopper system, brown coal is fed semi-continuously into the top of an open vessel, suitably insulated, and maintained at a pressure of about 300 pounds per square inch. Into the bottom of the vessel is fed a mixture of steam and oxygen. By incomplete combustion the coal is gasified (some oil being recovered as a by-product), the ash being withdrawn semicontinuously from the bottom. Technically, the process has been a great success. At Zittau the gas made has a calorific value of about 470 B.T.U. per cubic foot when freed of its carbon-dioxide content. Not long ago, at Most, Czechoslovakia, I had the privilege of inspecting in detail the last Lurgi installation built. Gasifying brown coal, sized 4–10 mm., they were producing a finished town gas having a calorific value of 570 B.T.U. per cubic foot. Had the oil distilled from the coal been returned to the generator for cracking, the calorific value of the gas made would have been in excess of 600 B.T.U. per cubic foot. The efficiency of the gasification step was in excess of 80 percent.

This installation was supplying gas, at

300 pounds pressure, to a 120-mile gas distribution system. A pipe line from Prague to Most is under construction, which will add another 70 miles to the distribution system. At present the Lurgi generation plant is being doubled in capacity. With the removal of some obvious bottlenecks, this installation could produce 15,000,000 cubic feet of town gas per day directly from low-grade coal, with a thermal efficiency of plus 80 percent.

As American engineering improved and cheapened the synthetic oil processes, so it can materially improve and cheapen the coal gasification process. Whereas the present Lurgi process utilizes a highly reactive, noncaking brown coal, there is no basic or fundamental reason why a high-caking, relatively inactive, bituminous coal cannot be gasified to yield a gas of 900–950 B.T.U. per cubic foot, with a thermal efficiency of plus 80 percent. Development work to achieve this is already underway. The first indications are that it will be successful. The economic equivalence of brown coal to town gas (gas with about 535 B.T.U. per cubic foot) having been demonstrated, the economic equivalence of bituminous coal to town gas and pipe-line gas should be shown within the next few years. Incidentally, our coal reserves are in excess of 3 trillion tons—enough for 2,000 years at present consumption rates. Converted to gas, this is equivalent to about 60,000 trillion cu. ft.—enough to last at the present rate of gas consumption approximately 1,500 years.

Dr. Alexander G. Christie has said, "Rising costs of natural gas and fuel oil assure the predominating position of coal as our leading reliance for energy production." To this statement I should like to add the thought that the extent to which oil and gas costs rise will be strictly limited by the widespread emergence of coal-to-gas and coal-to-oil processes. The economic equivalence of one to the other has already been partially shown. The demonstrable complete equivalence is but a few years hence.

So MUCH for the present "state of the art" in the transformation field. Oil made in Texas must be used elsewhere. Gas, if made from coal in West Virginia, will be used in more highly industrialized areas. The cost of transporting oil or gas has steadily decreased within the past decade.

The cost of transporting coal has not shown a corresponding decrease. In my opinion, the railroads are not wholly to blame for this lack of improvement. Beset as they are with rate-regulatory bodies on the one hand and rather inflexible labor policies on the other, they cannot quickly adjust themselves to maintain a competitive position with the ever-evolving and newer means of transportation. In the foreseeable future this inability to adjust themselves may react to their detriment.

The transportation of oil is an example. In 1939 the Class I railroad average rate, expressed in cents per barrel per 100 miles of straight-line distance, was 19.78 cents; a comparable rate for pipe lines was 3.92 cents per barrel. The rail rate was some five times larger than the pipe-line rate. During the war the operation of the Big Inch and the Little Big Inch showed what can happen to pipe-line costs when pipe diameters are increased, pumping equipment is made efficient and largely automatic, and load factor is kept high. A cost for the Big Inch comparable to the ones already given is 1.34 cents per barrel—about one-thirteenth of the rail rate. True it is that a comparison today of the Big Inch rate with the rail rate is largely academic—but in 10 or 20 years it may not be academic, and the trend has been shown. During the war we added 8,000 miles to our oil transportation system, of which 5,000 miles were product lines—lines largely in direct competition with the railroads.

Although I do not have specific and precise figures to show the decreasing cost

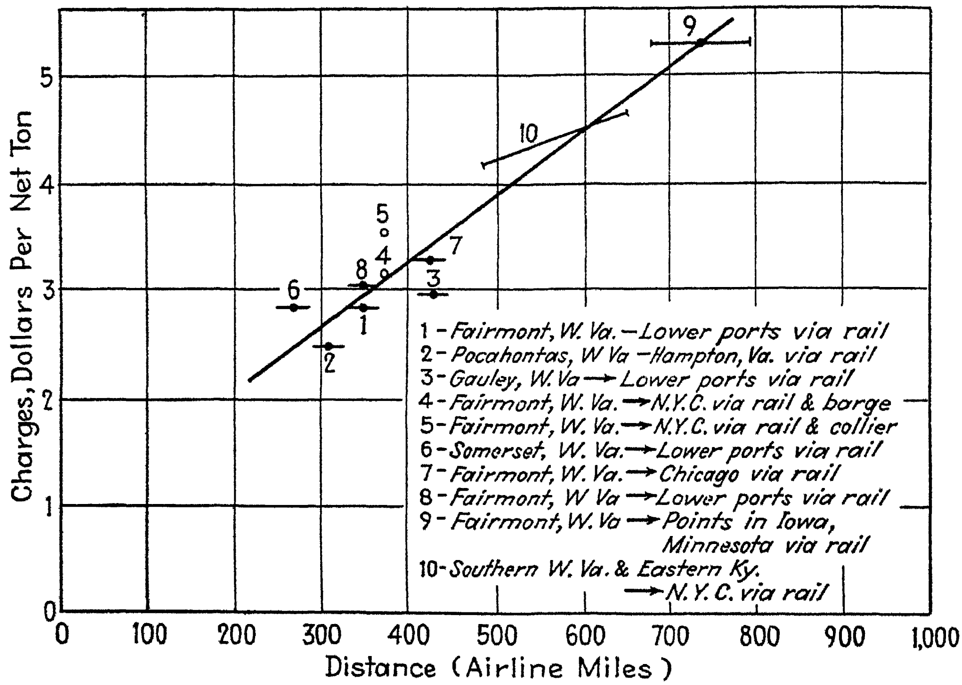


FIG. 1. SOME TYPICAL COSTS OF TRANSPORTING COAL BY RAIL

of transporting natural gas when larger-diameter lines and higher pressures are used, I am certain that postwar long-range gas transmission costs will be distinctly less than the prewar costs that were applicable to smaller-diameter, lower-pressure lines. A large-diameter gas line is now being laid from Texas to California, and there is much agitation to convert both the Big Inch and the Little Big Inch to gas service. The private capital responsible for the California line is sure the piping of gas long distances is a cheap way of transporting energy. Bidders for the Big Inch and the Little Big Inch were convinced that the use of these lines to transport energy from Texas to New York would be economic.

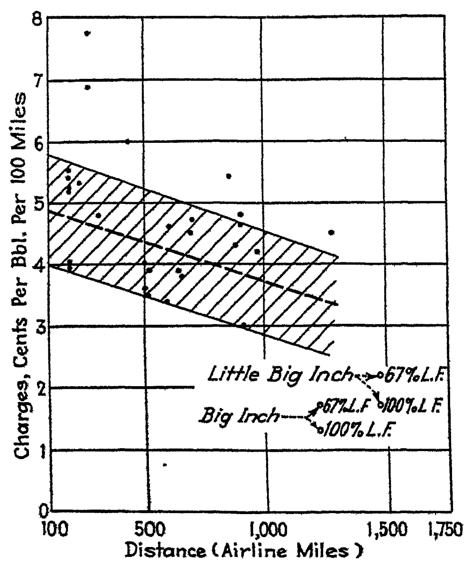


FIG. 2. OIL VIA PIPE LINE

COST OF TRANSPORTING OIL BY PIPE LINE.

If, then, in the future our main reliance for energy is upon coal, and if coal can be economically transformed into gas and oil, it will be interesting to compare the cost of transporting energy as coal to that of transporting an equivalent amount of energy as gas and oil.

Figure 1 shows some typical costs of transporting coal by rail and by rail and water. As a specific example, the average

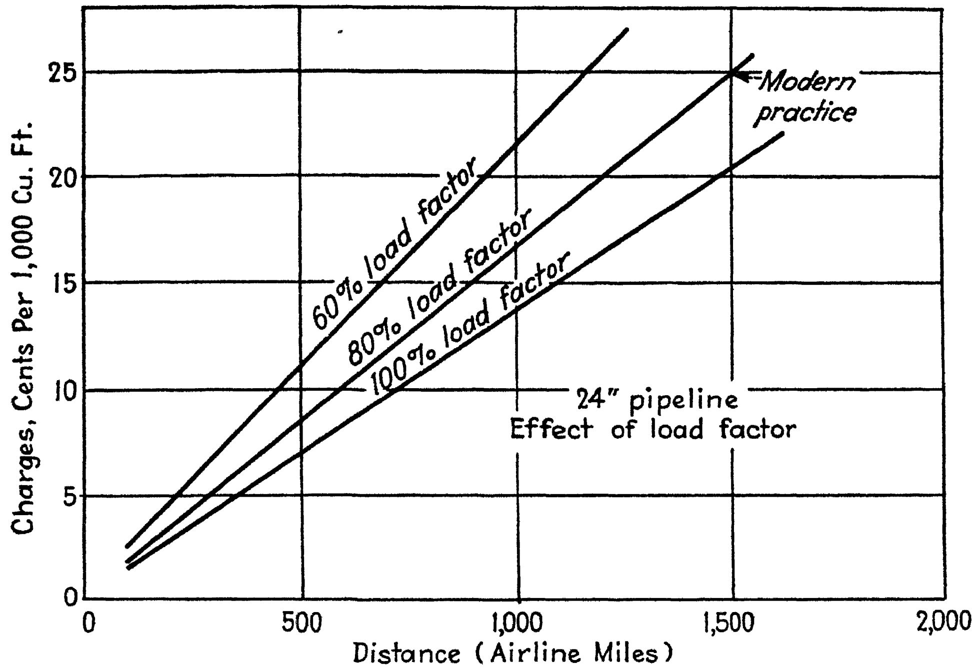


FIG. 3. COST OF TRANSPORTING NATURAL GAS BY PIPE LINE

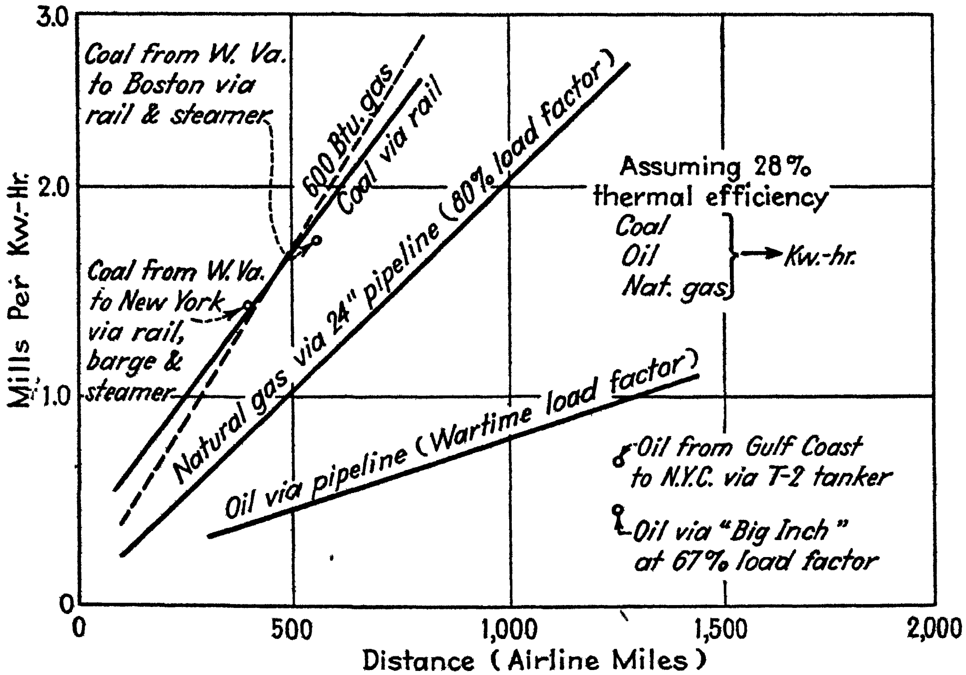


FIG. 4. RELATIVE COST OF TRANSPORTING VARIOUS FUELS

costs of transporting a ton of coal from West Virginia to New York City by rail and water is $3.35 per ton—a figure in excess of the mine-mouth production cost of the coal.

Figure 2 shows an attempt to average prewar pipe-line transportation costs. Take, for example, the cost for the Big Inch. Either at 100 percent or 67 percent load factor, the experienced costs were much lower than the average. On the assumption that a barrel of fuel oil contains 6,000,000 B.T.U., one may reckon that transporting the equivalent of one ton of coal from West Virginia to New York will cost 73 cents, a differential between the coal cost and the oil cost of $2.62 per ton. In other words, transporting energy as coal in this particular case costs three and one-half times as much as transporting the same energy as oil.

Figure 3 shows the cost of transmitting energy in the form of gas. For our particular case, that is, transporting 29,000,000 B.T.U. from West Virginia to New York (and in the subsequent discussion a 14,500-B.T.U. per pound coal has been assumed), the transportation cost for gas would be $1.92 versus $3.35. Again there is an incentive for the engineer to develop a process for cheaply gasifying coal and transporting this energy as gas.

Figure 4 compares transportation costs of the various fuels on a mills per kw-h basis. Since the production of 600-B.T.U. gas is already an established fact, I have shown a curve for the transmission cost of 600-B.T.U. gas (at 80 percent load factor) from West Virginia to New York. Transportation of this calorific value gas is about a standoff with the transportation of coal, assuming no differential advantage in the use of the gaseous fuel.

Either gas or oil is a more efficient fuel than coal, however. While very large high-pressure, high-temperature steam stations may achieve a thermal efficiency of 31 percent, a better average figure would be 28 percent. On the other hand, either Diesels or high-M.E.P. gas engines can, even in small sizes, achieve an efficiency of 34 percent. (Incidentally, the widespread, cheap distribution of gas and oil, coupled with the assurance that they would be readily available in the future, would be a great aid in the decentralization of industry.)

As I have said, there is every reason to believe that coal may be gasified into high-B.T.U. gas with a thermal efficiency of about 80 percent. Predicted operating cost for such an installation, exclusive of all fuel charges, is about $1.00 per ton. From the figures given here, one may reckon that when gaseous B.T.U.'s compete on an equal basis with coal B.T.U.'s, with coal worth $2.50 per ton in West Virginia, the transportation of a 900-B.T.U. gas begins to look attractive. If allowance be made for the superiority of gaseous fuel when compared to solid fuel, the transportation of 700-B.T.U. gas looks attractive. Certain it is that if the American engineer achieves his ambition of producing 1,000-B.T.U. gas from coal, at an efficiency of 80 percent, then the transportation of coal as gas will become a reality.

The figures for transporting coal as oil do not as yet look attractive. Even if coal were $1.00 per ton and allowance made for oil's superiority, the figures are disappointing. Again excluding fuel cost, the present predicted costs of transforming a high-B.T.U., low-moisture, low-ash coal into oil are over $5.00 per ton, or about $1.93 per barrel. Until the capital and operating costs of converting coal to oil can be decreased, there need be no fear of competition from oil made from coal. However, gasoline made from coal will in the near future compete with gasoline made from crude oil.

In conclusion, there is no impending oil shortage, there is impending competition between gas made from coal and natural gas, and there is impending competition between coal moved as gas and coal moved as coal.

TRENDS OF VOCATIONAL ACHIEVEMENT IN MENTAL DISORDER*

By ALBERT I. RABIN

Dr. Rabin (Ph.D., Boston, 1939) was born in Lithuania and came to this country at an early age. He has had numerous opportunities for investigations in abnormal and clinical psychology during his eight years as Chief Psychologist, New Hampshire State Hospital, Concord. He is President of the New Hampshire Conference for Social Welfare. Dr. Rabin devotes his spare time to tennis, swimming, and mountain climbing in the summer and to skiing in the beautiful White Mountains in the winter.

THE present study is an outgrowth of a more extensive investigation regarding patterns of mental functioning in psychiatric disorders. One thousand consecutive admissions to the New Hampshire State Hospital constitute the experimental population. These patients represent twenty-one psychiatric categories, including the major psychoses and neuroses, as well as some other minor disorders. With few exceptions the entire group is made up of adults under the age of sixty and is evenly divided into males and females. Educationally, since this group was selected at random, it corresponds very closely to the educational level of the general population as reported in the 1940 U. S. Census. Not only is there agreement as to the average grade achieved, but there is close agreement in the percentage of educational achievements at each of the several levels, that is, similar percentages of college graduates, high-school graduates, etc.

Disregarding possible fortuitous constellations of circumstances as well as the more specific economic factors, the level of vocational achievement is frequently a key to the individual's effective intellectual functioning. It is not only an indicator of the individual's intellect or capacity, but is symbolic of his "manifest intelligence" or effective wisdom in obtaining the more valued occupational status in our competitive culture. For this reason, the occupational levels of individuals suffering from various and sundry mental disorders become of interest to the investigator in this little-exploited field. Data obtained from such investigations may throw some light on one of the many moot questions in the field of psychopathology, namely: Is mental disorder a sudden attack upon the integration of personality, without premonition, or is it a slow, prolonged, and insidious process, which comes suddenly to a climax, but shows its effects, indirectly, through the life history and achievement *niveau* of the patient-to-be?

The case histories of the thousand patients were carefully checked, and the highest occupations achieved prior to hospitalization were recorded. In 61 cases no occupations were reported, since the patients were so young that they had no occupational opportunities prior to hospitalization. Also, 123 of the female patients were housewives with no other occupation prior to marriage. Thus, the final results concerning the patients' occupations were based on 816 cases; i.e., the total sample of 1,000 minus the 184 belonging in the above-mentioned categories. Classification of the 816 recorded occupations was especially facilitated by the recently published supplements of the *Dictionary of Occupational Titles*, in which thousands of occupations are coded and classified. The following are the major occupational classificatory categories, with their code numbers preceding them:

* Some of these findings were reported at the Boston meeting of the A.A.A.S., December 1946.

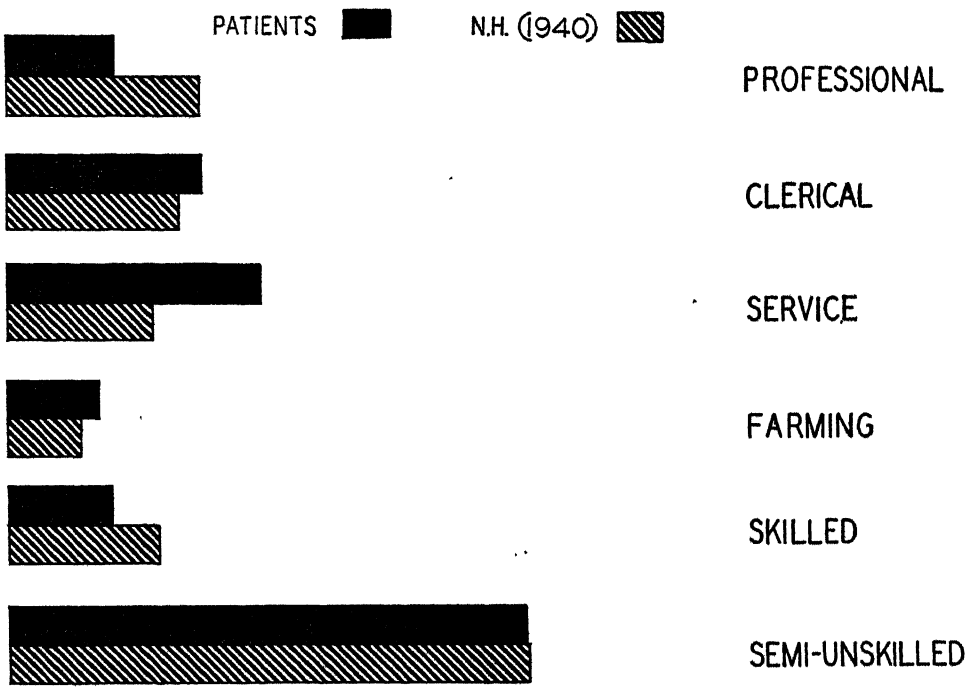


FIG. 1. A COMPARISON ACCORDING TO OCCUPATIONAL CATEGORIES

THE PERCENTAGES OF THE PATIENT GROUP IN EACH OCCUPATIONAL CLASS ARE COMPARED WITH THE CORRESPONDING PERCENTAGES OF GAINFULLY EMPLOYED ADULTS IN NEW HAMPSHIRE (1940 U. S. CENSUS).

0—Professional and managerial occupations
1—Sales and clerical occupations
2—Service occupations
3—Farm occupations
4–5—Skilled occupations
6–7—Semiskilled occupations
8–9—Unskilled occupations

An over-all view of the occupational status of the patient sample may be obtained from Figure 1. In this diagram the percentages of the patient group in each occupational class are compared with the corresponding percentages of gainfully employed adults in the state of New Hampshire (1940 U. S. Census). The last two occupational categories of semiskilled and unskilled occupations were combined, since the obtained data were insufficiently accurate to differentiate between them.

Upon examining the diagram our attention should especially be focused on the two points of maximum contrast. The first occupational category shows a most marked difference between the patient group (solid bar) and the state population as a whole (striped bar). The percentage of patients reaching professional and managerial status is only one-half of normal expectancy. On the other hand, the percentage of patients engaged in service occupations is almost twice the expectancy in the general population. The differences in the other categories are minor and not so clear-cut. Practically no differences are observed in the last, combined, category of the semi- and unskilled occupations.

A generalization that may be tentatively suggested on the basis of these results is that the patients show markedly lower representation in the occupations requiring higher intelligence, persistent effort and efficiency in competitive achievement, despite an educational level equal to that of

the general population. The data also suggest the tendency of the patient population to gravitate, possibly compensatorily, toward occupations requiring comparatively little skill, intellectual exertion, or arduous preparation. Thus, the general conclusion, in answer to the problem posited earlier, is that the process of mental disorder is apparently long and insidious and manifests itself much earlier than is ordinarily suspected in the afflicted individual's adjustment to his competitive society.

As was noted above, our sample was drawn from a psychiatrically heterogeneous group in which twenty-one nosological classes were represented. In view, therefore, of the findings concerning the occupational status of the patient sample, the question as to whether *all* psychiatric categories are equally responsible for the comparatively low occupational level becomes quite pertinent. If not all the disorders show a similar trend, which are the ones that are most effective in preventing the patient's achievement in the vocational field? The accompanying diagram gives at least a partial answer to this question.

Psychoneurosis, manic-depressive psychosis, and schizophrenia are three major psychiatric categories that constitute more than 50 percent of our total investigated population. The occupational levels of these three groups are compared in Figure 2. Most obvious, in the professional and managerial category, is the comparatively high percentage of neurotics and the extremely low percentage of schizophrenics, with manic depressives occupying a middle position. Almost twice the percentage of psychoneurotics is found in the professional

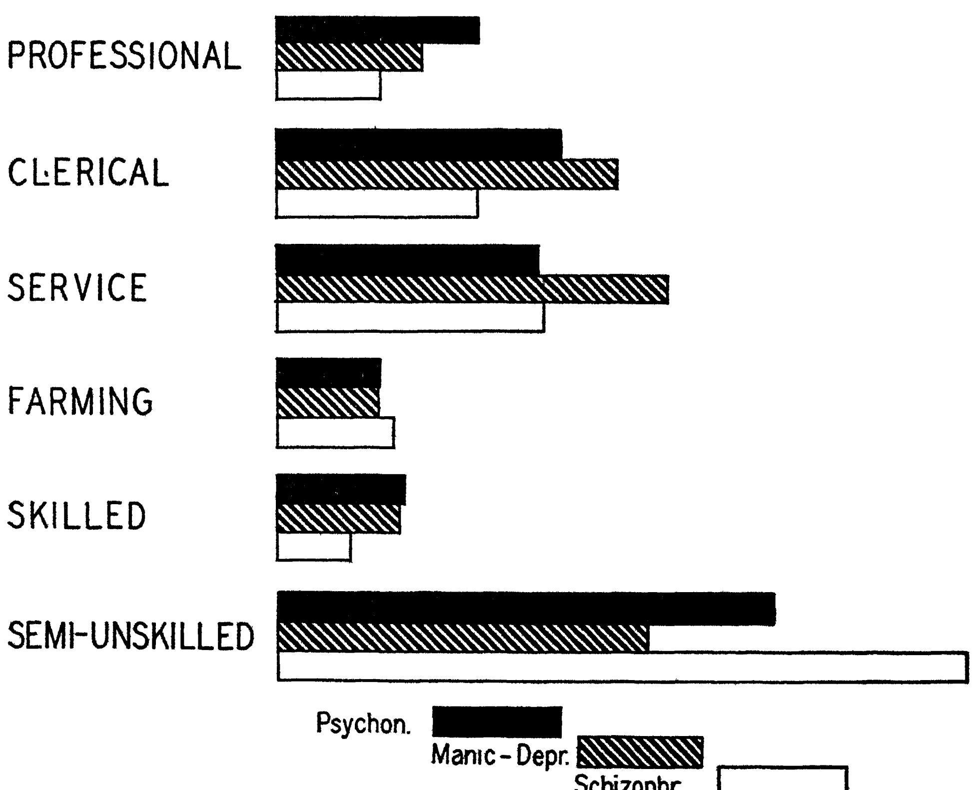


FIG. 2. DISTRIBUTION OF PSYCHIATRIC TYPES IN OCCUPATIONAL CLASSES

category when compared with the percentage of schizophrenic patients. This fact is especially striking, since the average educational achievement of the psychoneurotic is below that of the schizophrenic, the average grade completed in the former group being around 8.5 and in the latter, 9.5. Fewer significant intergroup differences are to be noted in the service and clerical (classes 1 and 2) occupational categories. A dominant manic-depressive trend is noted in these two categories, with psychoneurosis and schizophrenia falling fairly closely behind. All three disorders are almost exactly alike in the extent of their representation in the farming category. The percentages in the skilled occupations again reveal the comparative inferiority of the schizophrenic group. The percentage of psychoneurotics and manic depressives is almost twice that of the schizophrenics in the skilled-occupations category. Finally, the combined semi- and unskilled occupational classification shows up some further marked differences. Nearly one-half of all our schizophrenics are semiskilled or unskilled workers; about one-third of the psychoneurotics fall in this category, whereas only one-fourth of all our manic depressives are so classified. These percentages are especially interesting in view of their relationship to the educational level achieved by the respective groups. The manic-depressive group, with the lowest educational achievement (mean grade completed, 7.4) has the smallest percentage in the lowest occupational category, whereas the schizophrenics with the highest average educational attainment have the greatest representation in the lowest category.

When the data discussed above are taken into consideration, it quite clearly appears that in types of occupation requiring continuous effort and training, in the professions, management, and skilled occupations, the schizophrenic group lags markedly behind the two other major groups of psychoneurosis and manic-depressive psychosis. The difference in percentages at the higher occupational levels is made up by the schizophrenics by joining the ranks of the semi- and unskilled workers. The indications are, also, that the manic-depressive group, despite comparatively inferior education, is well represented in the more desirable occupations of our culture and less in the more undesirable ones, than are the schizophrenics. The psychoneurotics, with the exception of a large percentage in the professional category, present equivocal results.

In conclusion, an attempt to answer the second question raised may be made. Not all psychiatric nosological categories are equally responsible for lowering the occupational status of the total sample of the 816 patients studied. Schizophrenia is the one disorder, importantly represented in our population, that is chiefly responsible for the comparatively low occupational level of the entire patient group. In schizophrenia, the onset of the disorder is gradual, even prior to its overt manifestations, thus preventing early occupational adjustment commensurate with the individual's capacities and educational background and opportunities.

As a corollary of this conclusion, the question of the desirability of early spotting, by clinical personnel, of those individuals in whom is found the discrepancy between ability and educational achievement, on the one hand, and occupational status on the other, may be raised. Such a procedure may focus early attention to those individuals and should be one of the indications of a need for therapeutic measures.

PROBLEMS IN MAP EDITING*

By EDWARD B. ESPENSHADE, JR.

Dr. Espenshade (Ph.D., Chicago) is Associate Professor of Geography at Northwestern University. Prior to the war he spent seven years at The University of Chicago teaching elementary geography and building a large research map collection. In 1942 as Foreign Map Editor, Army Map Service, Corps of Engineers, he faced all the problems he describes, and many more, in preparing thousands of maps for the varied needs of global warfare.

World War I was fought over a relatively limited area, and the more intense action was over an even more restricted area. Action was largely stationary, as indicated by the name "trench warfare," and took place for the most part in well-mapped areas. The demand for maps, therefore, was limited, both in areas to be covered and in quantity, since as a rule only officers needed maps. The French mapping agency, the Service Géographique d'Armée, with some help from the British agency, the Geographic Section, General Staff, was able to supply these needs easily, largely from existing plates based on ground surveys. The United States Army had relatively little or nothing to do with map production.

The recent global war was in striking contrast. The airplane made complete coverage of the earth necessary on not one, but several scales. Ground operations on numerous fronts in widely separated areas required larger-scale maps, not just for parts of countries, but for part or all of several continents. The mobile nature of warfare made maps a necessity for enlisted men as well as officers. In both cases maps had to be prepared covering large areas for which basic surveys were lacking and for which information was scanty. Whereas the same sheet may have sufficed for several months in World War I, in World War II a soldier might have covered in a single day the area shown on several sheets at some scales. The result is that probably more maps were published in some months during World War II than during the whole of World War I. An operation like that in North Africa might require 15,000,000 maps, and annual production in this country alone might approximate 50,000,000 copies, involving from 5,000 to 10,000 different sheets. The enormous task of preparing military maps for field operations in World War II was assigned to the Geographic Section, General Staff, British War Office, including the Survey Directorates of the Commonwealth and Colonial governments, and to the Army Map Service, Corps of Engineers, U. S. Army, in this country. By agreement between the two agencies, the world was divided into areas of responsibility for map production.

Scope of types of maps. What were the types of maps required for military field operations? They fell into four broad groups: aeronautical charts, planning maps, maps for mechanized operations, and maps for infantry and artillery operations.

Aeronautical charts were the responsibility of the Army Air Forces, although the Army Map Service provided coverage for compilation and acted as printing contractor for them. These charts were for the most part on small and medium scales, but were planned for extensive coverage over the earth's surface. They included charts at scales of 1:5,000,000, 1:3,000,000, 1:1,000,000, and 1:250,000; for bombing-target charts, the scale might be as large as 1:75,000.

* From a paper read before the Washington Geographers' Club.

Most planning maps were on small scales, from 1:1,000,000 to 1:10,000,000. They included theater area and regional planning maps, strategic maps (usually over individual countries), communication maps for logistic planning, and such general series as maps belonging to the International Map of the World framework.

Maps for mechanized operations were usually on a medium scale, from 1:150,000 to 1:500,000. They were of a relatively general nature, with emphasis on roads.

Maps for infantry and artillery operations were on large scales, from 1:20,000 to 1:125,000. They were the common topographic map expressing surface configuration, cover, and cultural features in considerable detail. Large-scale city maps might also be considered in this group.

Methods of map production. Maps can be produced to provide the various needs just mentioned in any one of four ways or in various combinations of them.

1. They may be a reproduction of a ground survey; for example, a U.S.G.S. Quadrangle.
2. They may be a reproduction of a survey from air photographs; aerial mosaics might be included here along with maps drafted by trimetragon, multiplex, and other air-survey methods.
3. They may be the product of redrafting or mechanical facsimile reproduction in one or more colors of a previously published map.
4. They may be the result of compilation from several series of maps, possibly unrelated, and other source material.

Circumstances will decide which of the above methods or combination of them may best be used. The decision is determined generally by the information the map is to show, the source material available, the scale at which it is to be reproduced, and the time available for completion of the map. The last two methods were used for the greater number of the maps produced in World War II. Redrafting or mechanical facsimile reproduction is nothing more than copying an existing map, with possible revision and translation of border information and addition of the military grid. It is a method to be used when time is extremely short, and it is a procedure requiring a minimum amount of effort. The results are not always completely satisfactory: the date of the original map may be old, and the nature and appearance of the copy may give a reproduction not easily readable.

The last method, "compilation for an area," is the most difficult. It has been described as a "science" and as an "art;" it requires some of each. It involves evaluation of the accuracy and usefulness of all available source material; interpretation of the material and decisions concerning methods of using it; and incorporation of this source material into a unified map at the desired scale.

The editing problems discussed here are concerned primarily with compiled maps. Many of the compilation problems were the result of three factors: mass-production methods, necessitating the use of relatively untrained personnel; lack of knowledge of foreign maps; and lack of familiarity with the areas covered. The 1:1,000,000 map of South America, compiled by the American Geographical Society, is the only extensive foreign compilation job undertaken by an American agency, with the exception of the nautical charts of the U. S. Hydrographic Office and the Coast and Geodetic Survey. Done over a comparatively long period of years, it was possible to use highly trained personnel for direct supervision and even to check material in the field or with local authorities. In contrast, under war conditions the quality and nature of the map could be controlled only indirectly by preparation of specifications and instructions as detailed in nature as possible, and by relatively rapid inspections of the work at critical stages by competent, experienced personnel.

Source material problems. When a map is

to be compiled, the first step is the collection of source material, including maps and pertinent reports over the area. The nature of the source material selected depends, of course, on the type and scale of the map to be prepared; it may include all or only some of the following main types of materials:

1. Ground surveys, including completed or uncompleted field sheets of an area, town plans, and lists of geographical coordinates of various points, fixed by primary, secondary, or tertiary triangulation.
2. Air photographs, including systematically exposed strips of verticals, single photos or pairs of photos, and obliques.
3. General maps, including the following: (*a*) large-scale maps giving a representation of all physical features, both natural and cultural, which by their nature are usually based on ground or air surveys; (*b*) medium-scale maps, which give a conventionalized picture of a country and show all features that can be legibly drawn at the scale used; (*c*) small-scale maps used normally to give a broad picture of an area, on which features are generalized and information is often incomplete, but which help to show the various relations between features—for example, the relative importance of towns and major relief structures.
4. Charts, of various scales, which are useful primarily because of their detailed treatment of coastal features.
5. Communication maps, consisting of medium- and small-scale road and railroad maps. They may show details of the surrounding country or they may be diagrammatic. Road guides, timetables, and similar items may be included here.
6. Explorers' route maps; these may vary considerably from rough compass traverses, with brief notes, to detailed descriptions of routes, accompanied by aneroid readings and calculations of geographical positions by astronomical observations.
7. Descriptive material, including such diverse material as tourist guidebooks, textbooks, geographical articles from magazines, newspaper accounts, and military intelligence reports and summaries.

The collection of the source material in connection with a particular compilation job may require considerable effort and ingenuity; the task of analyzing and evaluating it requires qualities of scientific integrity and judgment. It is the most fundamental problem in editing a map. The result is an estimate of the relative accuracy and utility of each piece of material. In a simple compilation it is a mental process; in more complicated work it should be written. In either case it should systematically follow definite steps: the listing and appraisal of the material; comparison of the material; and a decision concerning its use. Let us examine each of these steps.

Listing and appraisal of the source material involves (*a*) drawing an index diagram in colors and showing in a generalized way the area covered by each source item; (*b*) listing information concerning the title, scale, publisher, date, and detail shown; and (*c*) preparing a statement of the reliability of each item. An accurate estimate of the reliability of any map or map series involves the analysis of many factors and sometimes can be ascertained only by careful and thorough research. If it is necessary to limit oneself to that information appearing on the face of the map, which is often the case, one is handicapped in an appraisal. Certain broad principles can be used, however, in an examination of the map on the basis of four factors: the authority, date, scale, and appearance of the map.

The authority is an excellent index to the reliability of a map. Established government agencies that are known to be in the business of making maps may generally be accepted as competent and reliable. A government agency responsible for a basic field-mapping program in a country is apt to be more reliable than agencies whose mapping is incidental to other activities. On the other hand, if a particular type of areal information is desired, such as roads, maps published by an agency responsible for road material are apt to be more accurate for that particular feature. At the same time, such "special-

purpose" maps may be unreliable for other features. For example, a map published by a department of roads may not be reliable for railroad information. It is a mistake, however, to assume that because a map is published by a government agency it is reliable. This is particularly true in the case of countries relatively backward in cartographic development and especially when basic field surveys have not been made in the area in question. A German map for a section of China published by the Reichsamt fur Landesaufnahme is apt to be more accurate than topographic maps made from reconnaissance surveys by the Chinese Government. Similarly, maps prepared in connection with flood and irrigation problems in North China by American engineering companies should be considered more reliable than official Chinese topographic maps.

It is somewhat more difficult to make generalizations concerning privately published maps. In the case of maps resulting from scientific expeditions, the reliability of the work can sometimes be ascertained from descriptive notes published with the maps. There are considerable differences in the accuracy, however, of many route traverses, and care is not always taken to report survey methods. For example, material published by Filchner in connection with his expedition into Central Asia, to make magnetic observations, appears to be much more reliable (probably because of the purpose of the surveys) than that of Roy Chapman Andrews, of the American Museum of Natural History. Privately published maps by commercial companies are subject to considerable variation. A few companies have world-wide reputations; others, such as Bartholemew, Michelin, and Jih Sin, have national reputations, which can be used as an index to selection of material. In some cases the reliability can be credited to a single man; for instance, V. K. Ting, in China, and Fujita, in Japan. It is apparent, then, that there is no unqualified generalization that is infallible, but by experience one can gradually develop ability to estimate the reliability of a map from a knowledge of authorities.

Dates are a second index to the value of a map and one which at first glance would seem to be a relatively simple one. On the contrary, they offer many difficult problems. They are particularly important because of the emphasis in military maps of having material as recent as possible. Unfortunately, many maps do not carry dates. This is especially true of those made by private publishers. They feel it may prevent sales; with the exception of such general items as road maps, I think this is a mistaken viewpoint. Many publishers, however, have codes from which dates may be ascertained. Some can be readily broken, others require information from the publisher. Lacking a date, one may be approximated from the time of purchase or acquisition; by comparing with another map of known date to determine, for instance, if a railway or road under construction has been completed; or by examination of the magnetic information. In some instances the style of the map may indicate its date.

Even though a map bears a date, one's difficulties may not be solved. The significance of the date may or may not be indicated. It may be the date of survey, compilation, publication, revision, reprint, or the latest edition; there may be only one date or as many as four. Further difficulty is encountered in the terminology applied to dates on foreign maps. Some twenty-four different phrases applying to dates are found on the Chinese General Staff 1:100,000 topographic maps; from one to three phrases may occur on a single map. Precise translations are difficult and often inconsistently applied. For example, the three terms "edition," "reprint," and "imprint" date, in English and in their various foreign counterparts, carry different implications, depend-

ing on the policy of the publishing agency. A new edition may involve major or minor changes; a reprint may involve considerable change, minor plate changes, or no difference between copies; and an imprint date may indicate minor changes that can be made on the press plate, or a new run with no differences. Of course, careful study can solve many of these problems or at least give an approximate answer. But time is often valuable, and days may be lost over a light table comparing editions of a large series of maps for emergency facsimile reproduction. A prime example is Central Europe, where several editions of a single map published by each of four countries may be available. Each map may carry from one to three dates with no indication of their significance. As a result of such problems, dated collation indexes for map series made up by different individuals located in London, Chicago, and Washington may result in the choice of the wrong sheet, since comparisons may not be possible and a common basis for dating cannot always be determined. The library of the Army Map Service has been working on a preliminary guide to dating methods for various countries, which should lead to more systematic results, if not the proper answer.

If one can solve the pure mechanics of dates, care must still be exercised in their use. If a date is that of an original survey, it is an important index to a map's accuracy. Land forms change very little within those time periods with which one deals in considering maps for military use, except along shore lines and meandering rivers. As a rule, therefore, general land forms as depicted by contours, hachures, and form lines may be accepted as being reasonably accurate regardless of the date of survey. It may be assumed, however, that prior to the extensive application of aerial photography to mapping, serious displacements of horizontal and vertical position may be encountered in extremely rugged and heavily wooded country, since such areas are difficult to delineate accurately in the normal use of ground survey methods. With respect to cultural features, the date of survey must be considered in relation to the normal expectancy of cultural change. Changes over a period of years may be minor or very extensive, depending on the rapidity of development of the region. In sparsely settled regions, maps from thirty to forty years old may be relatively accurate for cultural features. This does not hold, however, in some areas; for example, in Central Asia, where surveys may show the locations and names of nomadic settlements. By cumulative compilation, made by cartographers over many years, a map may contain many nonexistent settlements. Special symbols or the elimination of settlement locations in preference to tribal names should be used in such areas. In highly industrialized areas, extensive changes may render a map obsolete within a short time after publication. A knowledge of areas, however, often helps an individual to make further generalizations concerning the usability of features depicted on a map. In Central Europe the stabilized nature of the forest cover, owing to methods of forest farming, makes it feasible to accept forest cover from maps of relatively old dates.

Dates other than that of an original survey date are subject to considerable misconception. One assumes that when a compiler makes a map he uses the latest source material he can find, but how thorough was his search and how extensive were his facilities? Most maps fail to list the source materials used and fail to give the date of publication. These are some of the problems that result from dates on maps. Since time is an important factor, it is often necessary to accept a map as it is and to assume, if the original basis is sound, that the physical detail will not be changed greatly and that, though the patterns and populations of cities may be altered significantly, their general positions

and shapes will remain unchanged. The user of the map can be guided by a note giving the date of the original survey or publication of the map copied. Since communications are apt to be subject to considerable change and are of extreme importance in modern mechanized warfare, a fairly practical military map can be obtained by a revision only of communication features according to latest information, with a note giving the date and method by which they have been revised.

The scale at which a map is published may be helpful in indicating the accuracy of the original survey or compilation. It is normal cartographic practice to prepare original surveys and compilations at a scale somewhat larger than the final scale of reproduction. Therefore, the published scale reflects the accuracy of position and delineation of the original survey and likewise is indicative of the amount of detail which has been included or omitted. When several series of maps at different scales have been published over an area, care should be taken to note the order in which the original maps were prepared. If a first series published is at a large scale, a second series at a medium scale can usually be assumed to have been based on the first and larger series. In the case of the reverse situation, which amounts to the blow-up, or enlargement, of a series, care should be exercised. If the publisher redrafted the sheets in the process it is sometimes impossible to ascertain the facts. A position which may have a maximum error of 0.04 inch, or 200 feet on the ground at the scale of 1:62,500, may have a maximum error of 0.2 inch on the map at 1:12,000. The size of the conventional symbols used may increase this error further. There is little value to be gained from trying to compile a map on the scale of 1:100,000 from source material at 1:500,000. Compilers have not always been careful in this respect, and some medium-scale compiled maps should be used with caution. Map sources are full of cumulative errors from this faulty practice.

Finally, the general appearance and the detail of the map text may be a guide to its accuracy where there is no knowledge of the existence of ground surveys on a sound basis. Density of detail and types of features delineated are partially indicative. Improbable interpretations of geographical features revealed by examination may be a further clue. Are rivers shown in straight, sweeping lines in flat country? Are contours shown in smooth, parallel lines? Are villages shown without a road or track leading to them? Do streams run uphill? These and other improbable details should be watched for. It is advisable to read reports on the area involved before appraising its maps, so as to be able to observe any obvious contradictions that exist. In addition, examination of the map by an individual who has been over the ground the map covers may be valuable, although two difficulties present themselves: finding an individual who has been in the area, and ascertaining the trustworthiness of his knowledge.

Comparison of materials is the next step when the source material has been listed and appraised. Examination will have shown what pieces of information are available from each item of source material and what is common to several pieces. It is necessary to compare the common information to provide relative standards of accuracy for each feature. In some cases the base map or maps to be used can be established from the original appraisal. Features of other materials with the descriptive information gleaned from written sources can then be checked against this basic material for alignment, position, and classification. Sometimes no one map can be used as a suitable base for comparison of various features. Thus a different map may have to be selected as a basis for comparison of each feature. The relative standards of accuracy of features will be allotted automatically as

a result of the comparisons made. It is important to avoid a prejudice in favor of one piece of material during this process. Systematic tabulation by check list is one way to prevent short cuts leading to such prejudices.

With completion of the listing and appraisal of each item and the comparison among items, decisions as to the use of source material can be reached. These decisions are the basis for writing the instructions and specifications for the compiler. They should be clear enough so that there are no ambiguities and should visualize the problems that the compiler will meet and try to answer them. Each feature should be tabulated, and instructions given as to the source from which it is to be taken. Under mass-production methods, with relatively untrained personnel, the general accuracy of the map depends on the care with which these steps have been taken. A mistake in the selection of one piece of source material or in the treatment of one feature may destroy the ultimate value of the final map.

Problems of place names. Another major problem of map compilation that the global nature of the war accentuated was that of place names. In 1799 W. Eton, an Englishman, clearly defined a difficulty that geography has so far failed to solve:

> Where the orthography of names is established by long custom we must, I suppose, continue to use it.... Where this is not the case, we must spell names as the natives do, if they make use of the Latin characters; if we do not, we must either write their character, or make use of letters of our own alphabet that will produce, as near as possible, the same sounds; or without any regard to the sounds that answer to their letters. I will not decide which method ought to be followed, or which is the real language of a people whose orthography is fixed, the oral or written. I will only observe that it is very difficult to render the principal sounds of one language by letters of another, not to mention modifications; and this is particularly so to the English, whose vowels have very uncertain pronunciation.

The ensuing years of endeavor have failed to solve the problem of how to write geographical names for international use. Mr. Aurousseau, Secretary of the Permanent Committee on Geographical Names for British Official Use, commenting on the problem, says:

> The main question still remains open, as Eton left it in 1799. Time has secured, however, a small negative advantage. Belief in the possibility of international romanization has been shaken. Without an internationally accepted Roman alphabet, international romanization cannot be achieved, but the different values assigned to *c, g, h, j, v, w, x, y*, and *z*; the variety and inadequacy of devices for indicating aspirations, palatization, nasalization and yodization; and the poverty of means for indicating stress, quantity and tone, in western European alphabets, have defeated all efforts to establish one.

In the past relatively little progress toward a satisfactory solution of the place-name problem has been made. War on a global scale made some sort of solution necessary even though it might be temporary. Unfortunately, decisions had to be made under pressure of time, with comparatively little opportunity for research, and under influence of military requirements.

A geographical proper name serves to distinguish the place or feature to which it belongs from all other things. To prevent confusion in the use of military maps and in communications, there should be consistency in geographical nomenclature. But no international set of rules and principles has ever been agreed on and adopted. The result is that each country and publishing agency has adopted its own policy. The problem from a military standpoint is to establish a policy for treatment of place names that will lead toward consistency, if not actually achieve it: a policy that will enable the map maker in Washington, London, or New Delhi to take source material made under various editorial practices and arrive at a common result. The problem is twofold: that of establishing a suitable working policy, and putting the policy into effect.

Some of the questions which must be answered by a comprehensive place-name policy indicate the scope of the problem:

1. Should conventionalized names such as "Leghorn" for *Livorno* be used because they are so familiar?
2. Should there be a policy of conventionalized names for small-scale atlas maps and of local names for maps at a larger scale?
3. Should all names adopted by the International Postal Union be accepted?
4. Should names be written so that they can be pronounced easily or at least so that we think we can pronounce them easily?
5. Should all diacritical marks be eliminated because of cartographic and telegraphic transmission problems?
6. Should generic parts of place names always be translated, or should they be translated in some languages and not in others? Some people will not hesitate to translate the Russian word *Reka* into "river" in a place name, but will hesitate to render an Icelandic name such as *Vatnajokull* into "Vatna Ice-Cap," since the generic term and its associated specific part is written as a single word.
7. To go a step further, should the specific as well as the generic part be translated, especially if they are descriptive?
8. If an Englishman discovers and names an island which later becomes a French possession, should the French translation of the name be used if it occurs on official government maps of the area?
9. If the political sovereignty of an area changes should place names be affected?
10. Should the official government name be used in preference to a local name if a difference exists between the two?
11. When a country (such as Belgium or Switzerland) using the Roman alphabet has two or more official languages, which should be used?
12. When two or more countries use the same native language, but fall into different spheres of political control (e.g., Egypt, Algeria, and Spanish Morocco), should a common system of transcription be applied?
13. How should names of international zones and condominiums be treated?
14. If a feature is common to two or more countries with different languages, what name should be applied?
15. When should a local official name be used and when should a conventional English name be used in referring to bodies of water?

Non-Roman script languages and nonalphabet languages raise further problems:

1. Should an official transcription system when offered by a country be accepted?
2. Should transcription systems be letter for letter and reversible, should they be phonetic, or should some compromise be made between these extremes? Should they be broad or narrow systems?
3. If a system of transcription has been in existence for many years, should it be discarded in favor of a new and better system?
4. When no system exists, how does one develop a system acceptable to the various interests involved?
5. If numerous dialects of a language exist, or if it is spoken and not written, or if there is a difference between the spoken and written language, how should one proceed?
6. In nonalphabet languages, should hyphens be used to separate characters and what parts should be separated and capitalized?

Every one of these questions arose in connection with the preparation of place names on maps in the last war. For some, satisfactory solutions for the duration were reached. For others, no completely satisfactory solution can be found until research on the ground can be carried out. The scope of the problem, involving millions of names, made it impossible in most cases to work on the basis of individual name decisions. It was a problem of establishing rules and principles that could be applied to names for whole areas or countries and that would result in a treatment of place names at least satisfactory for the duration. Unfortunately, mistakes made cannot easily be erased because of the millions of maps involved and because of the great cost of transcribing millions of names from nonalphabet and non-Roman script languages.

From a military standpoint, the treatment of place names should accomplish at least five purposes:

1. A place name should always be spelled in the same way, not only on large-scale maps but also on small-scale ones. This consistency of spelling is of first importance.

2. Spelling insofar as possible should be that given on official government maps of the country involved. This is necessary because the maps provided for operations in an area may be partially compilations and partially facsimile copies of original official topographics.
3. A name that will be recognized locally is usually preferable to a name foreign to the area.
4. If possible the name should be written so that the soldier will be apt to give at least an approximation of the local pronunciation.
5. The rule or rules should be such that they are mechanically feasible in their fulfilment.

The United States Board on Geographical Names and the British Permanent Committee on Geographical Names each has established principles and laid down rules with respect to place names. They have been stated respectively in the *Sixth Report of the United States Geographic Board, 1890 to 1932* and in the British report *Alphabets of Foreign Languages*. Unfortunately, they apply only to English-speaking countries and have not necessarily been followed by other countries. In addition, the basic principles and rules are not sufficient to cover many existing problems. They provide an excellent foundation on which policies can be built.

It is not possible to examine each of these principles and rules here, but several of them should be mentioned. The local-name principle and Roman-alphabet rule are perhaps the more important. The seventh International Geographical Congress in Berlin, in 1899, decided that native names, established as accurately as possible, should prevail over all others. This principle has had its ups and downs. Today it is supported by both Britain and the United States. From it developed the Roman-alphabet rule, that local geographical names in each country, dominion, colony, protectorate, or possession in which a Roman alphabet (including Latin alphabets with modified or extra letters) is habitually or alternatively used shall be spelled in accordance with local official usage. In addition, accents and diacriticals should be retained if employed in the language of the country involved.

In practice this rule greatly simplifies the treatment of names over large parts of the earth's surface. It means that when compiling a map one can copy geographical names, with only minor reservations, directly from official maps published by the country that governs the area involved. Difficulty is encountered when there have been changes in the orthography of a country, as in the case of Norway, and when the official local policy of a country is not clearly defined, so that its own maps do not agree. When these problems arise it is necessary to adopt some expedient. As an example, the Dutch about 1935 adopted a change in their system of Malayan transcription involving the substitution of the letter "o" for the letter "å." On Army Map Service large-scale maps in the area it was mechanically impossible to make the change because many of the maps were facsimile reproductions. In addition, there are comparatively few people technically qualified to identify these Malay names among the thirty or forty other native languages in the area. On smaller-scale regional maps, International Maps on the scale of 1:1,000,000, and even on the scale of 1:250,000, the necessary changes have been made.

A second principle is that names written in non-Roman script should be transliterated or transcribed into our alphabet with as little loss of identity, either of sound or appearance, as is consistent with the process. This sounds simple; the accomplishment is difficult indeed. The rule that resulted from this principle is that names in countries which use non-Roman alphabets or scripts, or which have no system of writing, should be rendered in the English form according to the R.G.S. II System. This system is an alphabet, not strictly speaking an English one because it represents vowels as in Italian, developed by the Royal Geographical Society. It is followed also by the

U. S. Board on Geographical Names. This alphabet, for which comparative tables have been prepared for many non-Roman languages, does not completely solve the problem. Special tables have been prepared recently for Russian, Greek, and Serb. In a nonalphabet language such as Chinese, a completely satisfactory transcription system is difficult to devise. In southern Asia it is expedient to adopt the names used by the Survey of India, which has carried on ground surveys and published most of the large-scale maps in the area. These are a few of the exceptions to the general rule.

Space does not permit further discussion of the problem of place names. The revival of the Board on Geographical Names, with a large staff to do the necessary research in connection with existing problems, will help make satisfactory solutions available and will bring about consistency between map-producing agencies, at least in this country. There are other problems in connection with map editing that are as interesting and vital as the two I have discussed. Problems in connection with map design, the interpretation of foreign signs, symbols, and conventions, the preparation of glossaries, the size and style of type, and problems in connection with geodesy, such as projections and military grids, are examples of these.

In conclusion, one should remember that map making is not wholly a science; it is partly a subjective process involving qualities of integrity, judgment, and critical acumen. Unfortunately, a well-drafted and printed map has an appearance of accuracy. It is not like a printed text, in which statements can be carefully qualified, and it should be used, therefore, critically as well as with understanding. Mr. John Wright, of the American Geographical Society, has stated the situation excellently:

> Like carpenters' tools, maps should not be misused. More should not be expected of them than they can perform. Sometimes when a critic damns a compiled map because he has found errors on it in a region that he has visited, his condemnation may reveal ignorance of the nature of cartography on his part rather than carelessness on the part of the map maker. Not all maps can be based on new surveys. Errors that originated in the sources of a compiled map frequently could have been avoided only by not making the map.

BACK ISSUES WANTED

The unexpected addition of more than 2,000 new A.A.A.S. members between January 1 and May 1, 1947, has led to a shortage of copies of the February, March, May and June 1947 issues of The Scientific Monthly. *The reason for this shortage is that each new member in the first six months of the year has been sent back issues of the journal of his choice. Receipt of copies of these issues from members who do not maintain permanent files will be greatly appreciated. They should be sent to: American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington 5, D. C. Postage will be refunded.*—Ed.

CRIMINAL LAW FOR ATOMIC SCIENTISTS

By LEONARD H. LEVENSON

Mr. Levenson (B.S., Carnegie Institute, 1935), formerly a physicist and now a lawyer, is at home in both laboratory and courtroom. He has worked at the National Bureau of Standards, the Carnegie Metals Research Laboratory, and the U. S. Bureau of Mines, where he was physicist in charge of Navy work on explosion-proof electrical equipment. In addition to his private practice, Mr. Levenson is associated with the Legal Aid Society of Pittsburgh.

AMONG the minor repercussions of the explosion of the first atomic bomb was the linking together of two theretofore widely separated fields of knowledge — criminal law and nuclear physics. More exactly, the connection was made by the Atomic Energy Act of 1946, which, incidental to its general purpose of providing for the development and control of atomic energy, creates a number of new criminal offenses and specifies penalties for them. It is the purpose of this article to outline these offenses and penalties in conjunction with brief explanations of pertinent elementary principles of criminal law, and thus to dispel the unfounded fears of some physicists that nuclear research is to be greatly restricted under the Act and the illusions of others that such mundane matters as the Act and regulations issued under it are of no concern to workers in the ivory towers of pure science. As reassurance to the former, it is pointed out that one of the major purposes of the Act is, in its own words, "... assisting and fostering private research and development to encourage maximum scientific progress ..." in connection with atomic energy, and that restrictions on research activities have been kept to the minimum compatible with security requirements. As warning to the latter, on the other hand, it is pointed out that the penalties for violations of the carefully defined offenses in the Act are severe, ranging up to imprisonment for life and the death penalty itself, and that investigations of violations are expressly placed under the jurisdiction of the Federal Bureau of Investigation.

Before discussing its criminal aspects, the rationale of the Act will be given in order that the necessity for its various prohibitions may be better understood. Briefly, the Act seeks to control atomic energy by controlling the production, possession, and utilization of fissionable material, which is defined as meaning plutonium, U-235, or any other material capable of undergoing nuclear chain reaction. The title of all fissionable material is vested in the Atomic Energy Commission, which also owns all production facilities (plutonium piles, electromagnetic or diffusion isotope separators, etc.). The Commission may operate its production facilities itself or arrange for their operation by private contractors. Source materials (uranium, thorium, etc.) remain under private ownership, but all transfers must be licensed by the Commission. The manufacture of devices utilizing atomic energy, such as atomic-powered electricity-generating plants, must be licensed by the Commission. Generally, research activities are expressly exempted from these prohibitions. For example, Section 4 (*c*) (1), which provides for exclusive Commission ownership of production facilities, exempts facilities that are useful for research and that "... do not, in the opinion of the Commission, have a potential production rate adequate to enable the operator of such facilities to produce within a reasonable period of time a sufficient quantity of fissionable material to produce an atomic

bomb or any other atomic weapon." Clearly, an ordinary mass spectrograph, being useful for research and being incapable of producing (separating) U-235 faster than the order of one gram per century, would be exempted under this provision.

The offenses created by the Act may be divided into three general categories: (1) those pertaining to the control of information; (2) those pertaining to the possession of fissionable material, production facilities, and atomic weapons; and (3) those pertaining to reporting and inspection regulations issued by the Commission under the Act.

All offenses in the first category, together with their penalties, are contained in Section 10 (*b*) of the Act. This section, after defining "restricted data" as meaning ". . . all data concerning the manufacture or utilization of atomic weapons, the production of fissionable material, or the use of fissionable material in the production of power . . ." unless publication is approved by the Commission, prohibits the disclosing, obtaining, destroying, etc., of restricted data. Section 10 (*b*) (4), which pertains to destroying and whose wording is typical, is quoted below:

> Whoever, with intent to injure the United States or with intent to secure an advantage to any foreign nation removes, conceals, tampers with, alters, mutilates, or destroys any document, writing, sketch, photograph, plan, model, instrument, appliance, or note involving or incorporating restricted data and used by any individual or person in connection with the production of fissionable material, or research or development relating to atomic energy, conducted by the United States, or financed in whole or in part by Federal funds, or conducted with the aid of fissionable material, shall be punished by death or imprisonment for life (but the penalty of death or imprisonment for life may be imposed only upon recommendation of the jury and only in cases where the offense was committed with intent to injure the United States); or by a fine of not more than $20,000 or imprisonment for not more than twenty years, or both.

Stripped of its necessary but confusing synonyms, the above-quoted section makes it a crime to tamper with anything involving restricted data and used in connection with fissionable material or with federally conducted or financed atomic energy research, if done with a specific intent. If done with intent to injure the United States, the maximum punishment is life imprisonment or death, if the jury so recommends; if done with intent to secure an advantage to a foreign nation, the maximum punishment is imprisonment for twenty years.

The phrase "with intent to injure the United States or with intent to secure an advantage to any foreign nation" constitutes a very strong protection for the scientist against an unwarranted conviction for an inadvertent or noncriminal violation of the technical wording of the Act. For the commission of the crime, there must be both the criminal act and, in conjunction therewith, the specific criminal intent. The burden is on the prosecution of proving the specific intent required, and merely proving a general criminal intent will not suffice for a conviction. For example, suppose that a laboratory assistant, incensed at being discharged for incompetence, deliberately burns a laboratory notebook containing restricted data by way of wreaking personal revenge on his superior responsible for his discharge. He would be entitled to be found not guilty of violating Section 10 (*b*) (4), quoted above, because he lacked the intent to injure the United States or to secure an advantage to any foreign nation.

All the offenses pertaining to control of information, with one exception, require the above-quoted specific intents. The exception is Section 10 (*b*) (2) (*B*), which provides punishment for anyone who discloses restricted data ". . . with reason to believe such data will be utilized to injure the United States or to secure an advantage to any foreign nation. . . ." This would cover a situation where a susceptible scientist discloses restricted data to the beautiful spy familiar to every movie-goer. Even though his intent is only to win her favor and he has

no knowledge of her connection, he would be guilty of violating this section, for he would have reason to believe that her interest in atomic research was more than mere feminine curiosity.

Another protection of the atomic energy scientist in connection with control of information prosecutions is the provision of Section 10 (*b*) (5) (*A*) that no such prosecution shall be commenced except upon the express direction of the Attorney General of the United States, and only after he has advised the Commission with respect to such prosecution. Inasmuch as in the case of other crimes any person may commence prosecution merely by making a complaint under oath before a proper official, this provision is assurance that prosecutions will not be initiated before review by persons having the scientific background necessary for understanding the significance of the acts complained of, thus eliminating the danger of unwarranted prosecutions by overzealous and misinformed public officials or private individuals.

Still another protection is the provision of Section 10 (*b*) (6) that prohibits other government agencies from taking any action inconsistent with that of the Commission with respect to control of information. Thus, if the Commission permits the publication of data previously declared restricted, no other government agency can prohibit its publication, and the scientist is protected against conflicting orders and rulings from various government bureaus.

The penalties for offenses pertaining to fissionable material, production facilities, and atomic weapons are provided in Section 16 (*a*) of the Act, which provides as follows:

> Whoever wilfully violates, attempts to violate, or conspires to violate, any provision of sections 4 (b), 4 (e), 5 (a) (3), or 6 (b) shall, upon conviction thereof, be punished by a fine of not more than $10,000 or by imprisonment for not more than five years, or both, except that whoever commits such an offense with intent to injure the United States, or with intent to secure an advantage to any foreign nation shall, upon conviction thereof, be punished by death or imprisonment for life (but the penalty of death or imprisonment for life may be imposed only upon recommendation of the jury and only in cases where the offense was committed with intent to injure the United States); or by a fine of not more than $20,000 or by imprisonment for not more than twenty years, or both.

Section 4(*b*) prohibits the ownership by any person of facilities for the production of fissionable materials or the producing of fissionable materials except as duly authorized by the Commission; Section 4 (*e*) prohibits the manufacture or transfer of production facilities without Commission authorization by license; but exempts such manufacture or transfer when incidental to research; Section 5 (*a*) (3) prohibits any person from possessing or transferring fissionable material without Commission authorization, from importing or exporting fissionable material, and from producing fissionable material outside the United States; and Section 6 (*b*) prohibits any person from making or acquiring any military weapon utilizing atomic energy except as authorized by the Commission, but exempts research activities.

Unlike the first category of offenses, in this second category a specific intent is not essential for the commission of the offense; if present, the specific intent serves merely to aggravate the offense and increase the penalty. It is only necessary that the unlawful act be done willfully. In the language of criminal law, "willful" means voluntary and intentional and implies also a guilty mind.

To be guilty of an attempt to commit a crime, one must do more than intend and make preparations to commit it. He must commit an overt act tending to complete the crime and going beyond mere preparation. It is otherwise, however, in the case of conspiracy. If two or more persons agree to commit a criminal act, they are then guilty of the crime of conspiracy, even if they

subsequently change their minds and commit no overt act in furtherance of their agreement.

The penalties for offenses pertaining to reporting and inspection requirements are contained in section 16 (*b*), which provides:

> Whoever wilfully violates, attempts to violate, or conspires to violate, any provision of this Act other than those specified in subsection (a) and other than section 10 (b), or of any regulation or order prescribed or issued under sections 5 (b) (4), 10 (c), or 12 (a) (2), shall, upon conviction thereof, be punished by a fine of not more than $5,000 or by imprisonment for not more than two years, or both, except that whoever commits such an offense with intent to injure the United States or with intent to secure an advantage to any foreign nation shall, upon conviction thereof, be punished by a fine of not more than $20,000, or by imprisonment for not more than twenty years, or both.

Section 5 (*b*) (4) requires reports to the Commission of the possession, transfer, etc., of source materials; Section 10 (*c*) authorizes the Commission to require reports and inspections of atomic research activities carried on by private institutions under contract with the Commission and of activities relating to the utilization of atomic energy, and directs the Commission to require reports and inspections of the production of fissionable material in the conduct of research; Section 12 (*a*) (2) authorizes the Commission to establish health and safety regulations for the possession and use of fissionable and by-product material (nonfissionable radioactive material produced incidental to the production or utilization of fissionable material). Included in the catchall provision of this section would be a violation of Section 11 (*a*) (3), which requires that any invention or discovery useful in the production of fissionable material or in the military application of atomic energy be reported to the Commission within sixty days.

The Act also authorizes the Commission to apply for court orders enjoining violations or enforcing compliance with the Act, the Commission's regulations, and with subpoenas issued by the Commission in connection with hearings held by it. Failure to obey such a court order constitutes criminal contempt of court and, as such, is punishable by imprisonment.

There have long been criminal penalties on our statute books for physicians who unlawfully dispense narcotic drugs or who perform illegal operations, and for lawyers who embezzle clients' funds or who suborn perjury, but the existence of these criminal penalties has never been considered as impugning the professions of medicine or law as a whole. Similarly, the inclusion of criminal penalties in the Atomic Energy Act should not be viewed as a slur on the loyalty or integrity of atomic scientists, but rather as recognition of their new importance. Atomic science has now reached full stature as a profession in the sense that the activities of those engaged in it are a matter of such great public interest that the public must protect itself by criminal penalties against possible wrongful activities.

THE RESEARCH COUNCIL ON PROBLEMS OF ALCOHOL

By JOSEPH HIRSH

Mr. Hirsh has spent over a decade in the health and welfare field. Trained originally in the biological sciences, he took a graduate degree in sociology at Columbia University and is just completing his doctorate in education at New York University. During the war, among other assignments, he served as Public Health Education Officer on Nelson Rockefeller's staff in Central and South America and as Chief of Preventive Medicine, A.A.F , in Italy.

THE Research Council on Problems of Alcohol (60 East 42nd Street, New York City 17), a nonprofit, membership corporation organized in 1937 and incorporated in the District of Columbia in 1938, is an associated society of the A.A.A.S. The present membership of the Research Council is composed of approximately 1,000 individuals and groups. The privileges of membership include:

1. Participation in a major public health movement.
2. Subscription to the *Quarterly Journal of Studies on Alcohol.*
3. Subscription to the bulletin *Alcoholism.*
4. Reprint packets.
5. Research studies and publications.
6. Information services.
7. Technical consultation services.

The Council's objectives are to stimulate, initiate, sponsor (through grants-in-aid), and evaluate research in the problems of alcohol and in the treatment of problem drinking; to discover the causes and means of prevention of problem drinking; and to develop effective methods of diagnosis, treatment, rehabilitation, and specialist training.

The Research Council is primarily concerned with research and secondarily with education and information. Four problems have become manifestly clear to its administrative officers: first, that no single agency, operating in this field, can by itself render the large public service necessary to the solution of the complex research, medical, educational, social, and legislative questions involved in dealing with problem drinkers; second, that education—public and professional—and the creation of an atmosphere of understanding is necessary for the support of institutional and medical programs, scientific inquiry, and social action; third, that confusion exists in the minds of physicians, laymen, jurists and legislators, and public-spirited citizens as to methods needed to meet local problems; fourth, that the research and education undertaken heretofore have been, with few exceptions, too scattered and uncoordinated.

In an attempt to stimulate and establish research and treatment projects and standards of diagnosis, treatment, and rehabilitation, the Research Council has been working with and through such official and nonofficial agencies as the Veterans Administration, United States Public Health Service, American Medical Association, American Hospital Association, National Committee for Mental Hygiene, and others.

In the field of education, in an effort to establish public acceptance of the medical nature of problem drinking and of the need for research and medical action, the Research Council has been working with such voluntary agencies as the National Committee for Education on Alcoholism, the Yale School of Alcohol Studies, and certain religious groups and organizations.

Broadly speaking, the education and public relations program of the Research Council is designed to meet two needs: first, the dissemination of scientific information on the problems of alcohol in a socially useful manner through the distribution of publications reporting the best scientific data; and, second, the furnishing of adequate interpretation of the results of scientific inquiry through major media of information (that is, the press, magazines, and the radio and motion-picture

industries), so that intelligent social understanding and action may result.

In the first category, the Research Council has distributed tens of thousands of pieces of literature, both lay and technical, regularly to its membership and upon request to individuals and agencies. Within the past several months alone more than 9,500 pamphlets, technical papers, monographs, and reprints have been distributed either at cost or free of charge. In the second category, the Research Council is assisting newspaper and magazine writers and editors in the planning, review, and preparation of articles. Specialists within the Council are available and are serving as technical consultants in the preparation of motion pictures. Representatives of the Council have assisted, and are continuing to assist, in the development of radio programs, both local and network, on problem drinking.

In addition to those officers of the Council with permanent teaching affiliations, other officers are serving as guest and visiting lecturers before university classes, professional societies, and public groups generally in the formal areas of education.

With the cooperation of graduate students of hospital administration at Columbia University College of Physicians and Surgeons (School of Public Health), a master plan of inpatient and outpatient service in general hospitals for problem drinkers is being developed for the guidance of hospital administrators.

WITH the growing acceptance of the medical nature of problem drinking and the need for medical facilities for alcoholic patients, a number of states (and the Federal government, acting for the moment in the specific interest of the District of Columbia) have been pressing for legislation for the establishment of official commissions to study these questions and for clinic, hospital, and special facilities for the care of problem drinkers. Officers of the Research Council have assisted public and private groups in the analysis of proposed legislation and have testified in public hearings considering it.

Working with interested professional and nonprofessional private agencies, the Research Council plans to develop a framework of model national, state, and municipal laws and the recodification of existing laws pertaining to alcoholics, toward the end that these drinkers will come under the jurisdiction of health rather than of correctional authorities. This newly developed activity of the Research Council will assist present and future legislators and state commissions on alcoholism in the analysis of local problems and the preparation of adequate legislation to meet them.

Heretofore, research in this field has been largely segmentalized. In order to make it more effective, the Research Council is concentrating on a program of integrated research by establishing model research, diagnostic, treatment, and teaching centers in leading medical schools and their affiliated hospitals. Thus fundamental research and the preclinical and clinical sciences will be focused on the individual problem drinker in such a fashion as to develop sound scientific methods of diagnosis, treatment, prevention, and rehabilitation, as well as of education, both lay and professional.

In the field of research, the Scientific Board of the Research Council has reviewed approximately 200 individual projects in many areas. New proposals for research and requests for grants-in-aid reaching the Research Council from scientists will, upon approval, be incorporated in this program.

The first of several research, diagnostic, treatment, and teaching centers was established at Cornell University Medical College (The New York Hospital) in January 1947. This project was underwritten, for a five-year period, at the rate of $30,000 per year, by the Research Council, assisted by a special fund for research contributed by several leading companies of the licensed-beverage industry.

Among the "links" tentatively selected for the chain of centers are the New York University College of Medicine–Bellevue Hospital; the Langley-Porter Clinic, University of California, in San Francisco; and the Los Angeles County General Hospital, University of Southern California Medical School, in Los Angeles. The selection of these and other institutions is based upon their special interest, facilities, and personnel. The ultimate intention is to have the various researches undertaken by each "mesh" so as to cover the entire problem area without duplication. Cooperation in, and financial support for, these research centers are being sought from interested government agencies and from private foundations, industry, and individuals.

The future operations, both immediate and long-range, of the Research Council are visualized primarily as an extension and expansion of present activities. Serving, as the Council does, in part as a clearinghouse and in part as a stimulating agency, continuing relationships with both official and nonofficial agencies will be maintained for the following purposes:

Research:

To establish integrated research programs in terms of—

1. Fundamental research in colleges, universities, and research hospitals.
2. Research, diagnostic, treatment and teaching centers in such government institutions as Veterans Administration, U. S. Public Health Service, and state and local general hospitals.
3. Research centers or institutes in medical colleges and their affiliated hospitals and in certain selected general hospitals.

Service:

1. To assist in the provision of medical service to problem drinkers (Veterans Administration, U. S. Public Health Service—specifically, the marine hospitals—state departments of health, institutions and agencies, and public general and special hospitals).
2. To develop an over-all approach to problem drinking for the guidance of state health officers and for communities (U. S. Public Health Service, state departments of health, institutions, agencies, legislatures, and planning commissions).
3. To develop standards of differential diagnosis, treatment, prevention, and rehabilitation (The American Medical Association, The American Psychiatric Association, National Committee for Mental Hygiene).
4. To develop model Federal, state, and municipal laws for guidance in the provision of medical care for problem drinkers (The American Medical Association, The American Psychiatric Association, The National Committee for Mental Hygiene, The American Bar Association, and local affiliates).
5. To develop standards of operation of facilities for the medical care of problem drinkers, and a directory of accepted institutions (American Medical Association, American College of Surgeons, American Hospital Association).
6. To encourage the effective use of existing clinic, hospital, and other institutional facilities for the medical care of problem drinkers (The American Hospital Association, its state and local affiliates, and state departments of health, welfare, mental hygiene, and institutions and agencies.

Education:

To develop public acceptance of the medical nature of problem drinking and of the importance of scientific research in the solution thereof, through the major media of information and other agencies that have had long and fruitful experience in this field (Yale School of Alcohol Studies, National Committee for Education on Alcoholism).

While these are suggestive lines of future development and activity, growing out of the exigencies and demands of the past months, they are subject to modification and expansion.

ARRANGING MEETINGS OF THE A.A.A.S.

By JOHN M. HUTZEL
Assistant Administrative Secretary, A.A.A.S.

IN THE three years immediately following its first meeting on September 20, 1848, the A.A.A.S. held five meetings. In 1852 a meeting scheduled to be held in Cleveland was postponed because of an epidemic of yellow fever raging from the Ohio River southward. No meetings were held during 1861–65, or in the years 1942, 1943, and 1945 of World War II. With these exceptions, the Association has held at least one meeting each year of its existence.

The present-day efficient organization of the annual convention is due to the coordinated efforts of many scientists and lay personnel. First in order of a series of chronological events leading to the opening sessions is the selection of the convention city. During one of its meetings at each annual convention, the A.A.A.S. Council examines the invitations of scientists and convention managers in the larger metropolitan areas and makes its selection according to the facilities placed at its disposal and according to a policy of rotation of the meetings among the principal population centers. For adequate sleeping accommodations, the Association must have a guarantee of nearly 3,500 hotel rooms, and, because most participants desire to hold their meetings in the same hotel in which they have their room reservations, the Association must also have a guarantee of a sufficient number of hotel rooms to house about 300 sessions in six days, with provision for as many as 60 simultaneous meetings. Obviously, there are few cities large enough to provide these essential requirements; and, if meetings are to be held over a wider geographical area, it may be necessary eventually to set some sort of limitation on the number of sessions, or hold seasonal meetings in different cities, restricted to one or two sections and their related affiliated societies.

The date of the meeting is also set by the Council. Since 1902 nearly all annual meetings have been held during the week immediately after Christmas. The suitability of this time for the meeting is periodically reviewed by members of the Council as well as by the officers of the principal societies meeting with the Association. Consistently, the majority have always favored Christmas week in spite of the two major objections, that it immediately follows Christmas Day, and that it is in midwinter when the weather may be disagreeable. Generally speaking, however, it is a time when most conventioners are relatively free from academic and business duties. From the standpoint of obtaining sufficient sleeping and meeting facilities, the Christmas season is the most favorable, because during that period the hotels usually have fewer demands from other travelers.

Early in the year, officers of the A.A.A.S. visit the convention city to meet the sales managers of the cooperating hotels and to inspect the session rooms and facilities for the Science Exhibition. They also meet with representatives of local institutions to lay the groundwork for the organization of the local committees. The procedure usually recommended by these representatives calls for invitations from the Administrative Secretary, on behalf of the officers of the Association, to the heads of the major cultural, educational, and industrial institutions to serve as honorary chairmen of the meetings, and to appoint from their staffs persons particularly qualified to discharge the functions of com-

mittees on Finance, Reception and Entertainment, Registration, Equipment, and Publicity.

While the appointment of committee members is proceeding, letters are sent to the secretaries of all the societies affiliated with the A.A.A.S., inviting them to participate in the meeting. As rapidly as the invitations are accepted, general information about the meeting is returned, including deadlines for filing session-room and equipment requirements and copy for the *General Program.*

The responsibility for preparing the agenda for the special programs rests upon the secretaries of the sections of the A.A.A.S. and of the cooperating affiliated societies. These secretaries, with the help of their respective executive committees, decide the scope of subject matter for each session, the societies and sections which will meet jointly, the speakers, the dates and hours when the meetings will be held during the convention period, and the number of session rooms required. Moreover, they estimate the probable attendance at each meeting, which will determine the size of the rooms assigned for their sessions. To them is due the credit for furthering the aims of the Association through the organization of high-quality, distinctive programs.

The matching of session-room requirements with the session rooms made available by the hotels is done by one of the administrative officers of the Association in order to avoid the general confusion that would result should the secretaries compete with one another in obtaining preferred meeting places in the hotels. It is possible through this coordination to house societies with similar interests in the same or closely adjacent hotels. Scheduling of rooms is not, however, an easy task. Most of the sessions require rooms with a seating capacity of 100 or more, and, unfortunately, it is unusual to find a hotel having as many as six rooms with such a seating capacity. The average number is usually four rooms, varying in seating capacity from 100 to 1,500 or more. Cooperating with the hotels to reduce the costs of labor, the scheduling officer must assign sessions to the same room as often as possible throughout the convention, except in the case of meal functions, which, because of table arrangements, cannot be assigned to rooms occupied immediately beforehand. When one considers in addition the error inherent in estimating the probable attendance at a session six months in advance, it is little short of a miracle when the capacity of the room assigned approximates the actual attendance.

The majority of the 50 or more organizations cooperating with the A.A.A.S. meet for only two or three days during the convention period. Many of these meetings are on different dates, and by staggering the 250–300 sessions it is usually possible to accommodate all the sessions within the hotels. It is difficult, however, to make satisfactory assignments in the case of related societies, for these groups tend to ask for sessions on the same days in order to arrange joint meetings. As a result, it may be necessary to place some of the sessions in hotels other than those assigned as their headquarters, so that flow between sessions is less readily achieved.

As soon as local committee appointments have been made by the cooperating institutions, officers of the Association arrange to meet with each committee to assist in the formulation of plans and policies. The activities of these committees follow:

Finance Committee

Raise funds to meet the expenses of the general reception given to the officers, members, and guests of the Association and its affiliated societies, and to defray the cost of operation of all committees.

Equipment Committee

Procure projection apparatus, contract for opera-

tors, survey session rooms available outside the hotels, and organize teams to take care of emergency requests during the meeting.

Reception and Entertainment Committee
Supervise all arrangements for the general reception, organize special tours, and provide for the entertainment of the women attending the convention and for special entertainment features such as symphony concerts and choir recitals.

Publicity Committee
Publicize the meeting locally, assist in coordinating radio programs, and equip the press room.

Registration Committee
Organize the physical arrangements for registration, establish information centers, and provide special leaflets and other literature describing eating and transportation facilities.

Following a general discussion of these functions, each committee elects its own officers, including a chairman. Collectively, the chairmen constitute the local *Executive Committee*, which in turn elects the general chairman of the convention.

After the initial meetings, the activities of the local committees are largely autonomous. As hosts of the convention, the committee members assume many more functions than have been outlined here, not a few of which exact a great deal of energy and require a generous contribution in time and patience.

By mid-June much of the groundwork for the convention has been laid. During the summer months bids are solicited and contracts awarded for the Convention Badge and for printing jobs, including the *General Program* and registration forms. Not again until September, however, is there an acceleration of activities, when publicity plans are pressed and the secretaries of the sections and societies drive toward the completion of their programs.

One of the Association's aims, as expressed in its constitution, is to "increase public understanding and appreciation of the importance and promise of the methods of science in human welfare." It has, therefore, the task of bringing before the public through press and radio the reports of the scientists who participate in its meetings. Annually, seventy or more press representatives cover the convention, including many members of the National Association of Science Writers, an affiliated organization. Facilities to aid them in their work are provided by the local Publicity Committee and supervised by a press director, who, prior to the meeting, is charged with the responsibility of forwarding advance copy obtained from the authors to press bureaus and science writers throughout the nation.

It is obviously impossible to direct public attention to more than a small fraction of the 1,300–2,000 papers presented at the meeting. Not only do many of the papers lack news value, but few science writers have the time, let alone the background, to adequately interpret on a popular scale reports from the widely varying fields of science. Unfortunately, also, there appear to be only a few scientists who can report their work in a manner both clear and interesting to the layman. And as specialization becomes more intense, there are many subjects that resist popular interpretation. As a result, the secretaries of the sections and societies are called upon to evaluate the papers to be given on their own programs and select those which in their opinion represent outstanding contributions to the advancement of science. A complete copy of each chosen paper, together with an interpretive abstract by the author, is then forwarded to the press director, who sends mimeographed copies to accredited science writers and also provides copies for press-room distribution during the meeting. To reduce the hazard of inaccurate reporting that sometimes results from the race to meet deadlines, it is necessary that these papers and abstracts be in the hands of the press director at least two

weeks before the meetings. Copies can then be forwarded to the science writers in time for them to study and interpret the subject matter or seek authoritative advice if necessary. To ensure general distribution of his report, each author is urged to send 50 copies of his paper directly to the press director well in advance of the meeting.

The secretaries also forward to the press director abstracts of all the other papers to be presented at their sessions. These are kept on file for the inspection of writers before and during the meeting. The Association reserves publication rights only on papers presented at its general sessions and before its sections. No other papers are reviewed for publication by the editors of *Science* or THE SCIENTIFIC MONTHLY. For publication in either of these journals, manuscripts of papers presented before meetings of the societies must be submitted directly to the respective editors.

Few meetings offer more material suitable for broadcasting than the meetings of the A.A.A.S. For six days, workers in all the major fields of science, from all parts of this country and many foreign countries, are congregated in a large city with ample broadcasting facilities. Scheduled for discussion are subjects having local, regional, and national interest—subjects readily translated into forum- or interview-type radio programs. In organizing the programs of the sections and societies, the secretaries are asked to suggest topics and panels of speakers. These are submitted for approval to the managers of the local radio stations, and those selected are referred to the proposed participants with notice of probable date of live broadcast or recording for delayed broadcast. Shortly before the convention, final schedules are worked out and arrangements made for preliminary discussions in the convention city between the speakers and the station representatives.

As the programs of the sections and societies materialize, a synopsis of each is printed in one of the Association's journals, along with general announcements of meeting arrangements, including the hotel headquarters assignments and room reservation forms. An A.A.A.S. Housing Bureau is established in the convention city. Guests seeking sleeping accommodations list three hotels in the order of their preference, and placement is made according to the availability of the type of room requested at the time the reservation is received. Assignment in the hotel of first choice is more likely in those cases where friends are willing to share rooms than when requests are made for the less numerous single rooms. The Housing Bureau may save the conventioner much needless correspondence in obtaining room reservations, for if accommodations are not available at the hotel of first choice, the reservation request is quickly referred to other hotels.

Concurrently with the development of the programs of the sections and societies, the administrative officers of the A.A.A.S. organize a number of general and special sessions such as award ceremonies, the A.A.A.S. Business Meeting, the Academy Conference Dinner, the Secretaries' Luncheon, joint meetings with the Society of the Sigma Xi and Phi Beta Kappa, exchange lecture with the British Association for the Advancement of Science, and others. These programs are designed to give leading educators, research specialists, statesmen, and industrialists an opportunity to express themselves before a general audience on subjects of current importance to all scientists.

Toward the end of September the secretaries are reminded of the deadlines set for the submission of program copy, equipment needs, abstracts for the press, and broadcasting plans. The *General Program* is made available December 1 in order to permit the conventioner time to study the entire

agenda and decide which sessions to attend. Those who wish to register in advance may obtain a copy of the *General Program* before the meeting by sending the registration fee to the Assistant Administrative Secretary of the Association before December 1.

In order that the program may be available for mail distribution, it is necessary that program copy be submitted to the Washington office not later than October 21. It is desirable to have as much copy as possible from the secretaries of the sections and societies prior to this date so that it can be retyped to conform with the standard style and so that the galleys can be corrected in time to meet the printer's deadline of November 15. Approximately two weeks are required to print and bind the programs and prepare them for mailing after the final corrected proofs have reached the printer.

A schedule of the equipment requirements for each session is filed with the Association at the time the program copy is submitted. These schedules are forwarded to the chairman of the local Equipment Committee, who arranges for the rental of projection apparatus and the hiring of union operators. As a rule, union operators must be paid a flat rate of so much a session, regardless of the time actually spent in operating the machines. Projection of but a single slide therefore costs as much as the continuous showing of slides for a three-hour period. Moreover, some unions require a different operator for each type of projection apparatus. Most meetings of the Association require twenty $3\frac{1}{4}' \times 4'$ and twelve $2' \times 2'$ slide projectors, as well as six or more 16-mm. motion-picture projectors, because of the large number of sessions needing projection equipment that may be in progress at the same time. Other types of projectors and special adapters are often needed for the 130 or more sessions using equipment of this kind during the convention period. Members of the local committee visit each room scheduled for projection and determine the position of the machines according to the focal length and size of screen necessary to provide optimum visibility to a capacity audience.

In addition to projection apparatus, microscopes are needed for demonstration programs, along with special laboratory accessories that frequently must be obtained directly from the manufacturers. Public address systems are required for all the larger meetings. The cost of providing equipment and arranging for storage, transportation, and insurance is approximately $2,000. This is not a large sum, but it does add substantially to the total expense of the meeting, which is estimated to be $28,000, exclusive of the charges sometimes made for the use of hotel session rooms. The secretaries are therefore urged to schedule papers requiring projection apparatus in one or two sessions, and to accede to requests for equipment only in the case of demonstration programs or if absolutely necessary for clear exposition.

In general, the costs of the meeting are defrayed by income from three sources: registration, the Science Exhibition, and funds raised by the local Finance Committee. If the income is insufficient to meet expenses, the deficit must be paid out of the Association's reserves. These reserves are derived solely from the membership dues and operations of the Association, for the affiliated and associated societies do not contribute in any way to the financial support of the A.A.A.S. Members, and particularly nonmembers, who attend the convention should therefore register, so that expenses will be borne on a prorata basis by those who benefit directly. Registration is not compulsory, but it is difficult to understand the attitude of those who fail to register and at the same time take the advantages of the meetings.

A week or two immediately in advance of the meeting administrative officers of the Association establish headquarters in the convention city to help direct last-minute preparations. Meetings are held with members of the local committees for a general review and summary of their activities and to fix the division of labor that will hold throughout the convention. The session-room assignments of each hotel are examined, and consultations are held with the program directors of the radio stations to confirm broadcast commitments. Of particular importance are the preparations for registration and the construction of the exhibits.

Registration facilities are so arranged as to reduce to a minimum the amount of time necessary to register. Upon presentation of the registration card and fee to an attendant, the convention guest receives a Convention Badge, a copy of the *General Program*, and special literature provided to familiarize those from out of town with the host city. The main registration center is located adjacent to the Exhibition, and, depending upon the disposition of the headquarters hotels and other meeting sites, auxiliary registration desks are set up at places convenient for scientists attending the meeting. Small groups holding their meetings at some distance from the main center of activities are not provided with registration facilities, and it is therefore advantageous for their members to register in advance of the meeting.

Many services are provided conventioneers at the main registration center in the Exhibition area. Attendants at the information booth advise registrants about the meetings, transportation, eating facilities, and local points of interest. They also operate a lost-and-found service. Mail and telegrams addressed in care of the A.A.A.S. are held there, and every attempt is made to notify the addressees. The Association does not, however, assume responsibility for their delivery; communications not called for during the convention are returned to the sender. A visible directory also is maintained to assist registrants in locating friends and business acquaintances during the convention.

The Advertising Manager of the A.A.A.S. administers the Science Exhibition held in conjunction with the annual meeting. This is a difficult task, requiring the solution of numerous technical problems during its assembly the week preceding the convention. The exhibits are intended to offer scientists the opportunity to examine at close range recent developments in pure and applied science. Attendants are on hand at the exhibition booths to explain the displays and assist interested persons in selecting equipment or procuring materials to meet their own research requirements. Out of revenue derived from the rental of exhibition floor space to commercial concerns, which, for the most part, are interested in displaying scientific books, apparatus, or supplies, the Association sponsors a large number of special exhibits of outstanding examples of scientific research by individuals, government agencies, or nonprofit institutions.

Aside from newspaper and radio accounts and the activity in the press room, no fanfare accompanies the opening day of the convention. The schedule of meetings, as well as synopses of the programs of the sections and societies, have been given local and national publicity through the Publicity Committee and through the journals of the Association and of the cooperating societies. Thousands of scientists converge on the host city, check in at the hotels, and begin to pursue various activities in connection with the convention. For those who have helped organize the meeting, tension is at a peak. Regardless of the best-laid plans, during the six days of

the meeting countless new problems arise that need quick, positive solutions. Association personnel are stationed at the headquarters hotel and at the Exhibition, where they may be readily reached for assistance. Each session is under the supervision of a presiding officer who, if he possesses foresight, examines the facilities for his meeting at least half an hour in advance to make certain that all is in order and, if not, to call on the officers of the A.A.A.S. for quick adjustments. In general, however, the die is cast, and most of the meeting activities proceed according to plans formulated months before the opening date.

NOR GAUGE THE FRUIT

Not on the surface fix your gaze,
But telescope above, below.
Penetrate the outer glaze . . .
Discern the embryo.

Stretch the vision till the sight
Rests past the moon, behind the sun;
Look deep into the pit of night,
Into the well of dawn.

Nor gauge the fruit by downy skin,
But let the tongue explore
The secret succulence within—
And learn the bitter core.

Knowledge wears a subtle guise;
Her countenance is seen
Only by those who scrutinize
Below . . . above . . . between!

MAE WINKLER GOODMAN

THE CATS-TO-CLOVER CHAIN

By W. L. McATEE

For more than forty years Mr. McAtee was a member of the Fish and Wildlife Service (U. S. Department of the Interior), where he made a reputation in economic ornithology and systematic entomology. His studies of blind fishes caused him to doubt much natural-selection doctrine, and his investigations of the food habits of birds led him to challenge it. A book manuscript, "A Critique of Darwinism," has found no publisher, however. His principal task and pleasure at sixty-four is the preparation of "A Dictionary of American Bird Names."

AT LEAST every hundred years or so, the arguments of science should be re-examined. Among natural-selection speculations, a few have been time-revised, and it is proposed to deal with another here. The doubted remarks are contained in the following disquisition by Charles Darwin on the pollination of heartsease and red clover.

> Humble-bees alone visit red clover, as other bees cannot reach the nectar. It has been suggested that moths may fertilize the clovers; but I doubt whether they could do so in the case of the red clover, from their weight not being sufficient to depress the wing petals. Hence we may infer as highly probable that, if the whole genus of humble-bees became extinct or very rare in England, the heartsease and red clover would become very rare, or wholly disappear. The number of humble-bees in any district depends in a great measure upon the number of field-mice, which destroy their combs and nests; and Col. Newman, who has long attended to the habits of humble-bees, believes that "more than two-thirds of them are thus destroyed all over England." Now the number of mice is largely dependent, as every one knows, on the number of cats; and Col. Newman says, "Near villages and small towns I have found the nests of humble-bees more numerous than elsewhere, which I attribute to the number of cats that destroy the mice." Hence it is quite credible that the presence of a feline animal in large numbers in a district might determine, through the intervention first of mice and then of bees, the frequency of certain flowers in that district![1]

In examining the quoted passage, the first need is for a polite way of contradicting one hailed as practically infallible. However, we may say with respect to the assertion "Humble-bees alone visit red clover, as other bees cannot reach the nectar" that, as a whole, it involves a *non sequitur* and that the first part of it is untrue. The basis for these strictures will come out in discussion of the inclusive topic of the role of what in America are called "bumblebees" in pollinating heartsease (*Viola tricolor*) and red clover (*Trifolium pratense*). Darwin says: "We may infer as highly probable, that if the whole genus of humble-bees became extinct or very rare in England, the heartsease and red clover would become very rare, or wholly disappear." This statement ignores the fact that the smaller, paler-flowered forms of *V. tricolor* are regularly self-pollinated (letter from J. W. Dutton, Ministry of Agriculture, London, January 21, 1935) and that honeybees are active pollinators of *T. pratense*.

Experience with red-clover pollination in England, where honeybees are maintained in numbers, can scarcely differ from that in the United States. Here, in an investigation by the Colorado Experiment Station,

> Honeybees were found to be carrying red-clover pollen. A large percentage of the bees observed were active pollinators of red clover. These insects are a major factor in pollination of this plant in Colorado, east of the mountains. [The author adds]: The length of the corolla tube apparently has no bearing on red-clover pollination by honeybees.[2]

Federal Department of Agriculture authorities bear out the last remark, saying, "Honeybees visit red clover principally for pollen and seldom obtain nectar, but regard-

less of what is obtained, pollen is transferred and cross-pollination is effected."[3]

As a conclusive instance, Ohio investigators found during a three-year study of red-clover pollination "that more than four-fifths of the total pollination services was performed by honeybees" and recommended that clover-seed producers maintain as large a number of colonies of these bees as they profitably can.[4]

These quotations would seem to dispose of the claim that bumblebees are indispensable as pollinators of red clover. Even if they were, dependent parts of Darwin's argument do not follow. He refers to destruction of bumblebee nests by field mice, and of the mice by cats, and concludes: "Hence it is quite credible that the presence of a feline animal in large numbers in a district might determine, through the intervention first of mice, and then of bees, the frequency of certain flowers in that district!" He might as well have started the chain with old maids, as some innovators have, and then gone on to include the success of agriculture and possibly the fate of the nation, as red clover is a leading forage crop and heartsease a prime weed. Domestic cats certainly do not as a rule regulate the population of field mice; they prefer an easier way than that of making a living. American studies show that at least half the food of prowling cats consists of garbage. The role of field mice in destroying bee nests was in turn overestimated. The late Dr. T. H. Frison wrote me:

> I have called attention to the fact that queen bumblebees make extensive use of mice nests when founding colonies I have good evidence that mice at times kill out some of these new colonies but I believe that any harm done to bumblebees by rodents is more than offset by the use that bumblebees make of the deserted nests of small mammals such as mice (Letter, March 7, 1935).

F. W. L. Sladen, a British authority who has much the same to say about the relations of field mice and bumblebees, further states:

> I cannot corroborate Col Newman's statement, quoted by Darwin, that humblebees' nests are more numerous near small towns than in the open country, believed to be because the cats in towns keep down the field mice, and think this must be the case only in particular localities.[5]

Darwin's argument in this case thus does not stand up under the findings of later studies and does not deserve the wide circulation it has received.

REFERENCES

1. DARWIN, CHARLES. *The Origin of Species*, etc. Chicago and New York: 189–, 55.
2. RICHMOND, R. G. Red-clover Pollination by Honeybees in Colorado. *Colo. Exp. Sta. Bul.* 391, 1932, 19.
3. PIETERS, A. J., and HOLLOWELL, E A. Clover Improvement. *U.S.D.A. Yearb.*, 1937, 1199.
4. [RAMSOWER, H. C., Director.] Honeybees Increase Clover Seed Production Fifteen Times. Ohio State University and U.S.D.A., cooperating, 1943, 3, 4.
5. SLADEN, F. W. L. *The Humble-bee ... with Descriptions of all the British Species of Bombus and Psithyrus*. London: 1912, 118.

KOREAN SCIENTISTS ORGANIZE

By FRANK L. EVERSULL

Dr. Eversull (Ph.D., Yale, 1934) has been a clergyman and a college president. His mission in Korea was as Chief of Colleges and Teachers Colleges. In February of this year he returned to his home at Columbia, Ill., for a few weeks, or perhaps months, of writing and speaking.

PREAMBLE: In order that the scientists of Korea may have greater opportunities for scientific study and research, that scientific knowledge may be made more readily available to enrich and enhance the social, economic and industrial life of our nation, that we may cooperate in our efforts to spread the results of scientific research and study and that we may honor our great scientists, we do hereby adopt this Constitution and these By-laws of the Korean Association for the Advancement of Science and the Korean Academy of Science."—From the adopted Constitution of the Korean Association for the Advancement of Science and the Korean Academy of Science.

WITH the beginning of a new day in Korea there is a distinct trend on the part of the leaders of that country to organize themselves for national advancement. With no group has that been more apparent than among the intellectual leaders. As the scholarly pursuits began to take form after the American occupation and as the leadership of the country began to assert itself, there was a growing disposition to study the problems of the new Korea and to take steps to promote those arts and sciences that were necessary for the growth and development of a new nation.

In August 1946 the Military Governor proclaimed Ordinance 102, which established the National University of Seoul. Its predecessors had been the Chosen Imperial University, a part of the Japanese educational system, and a number of public and privately owned colleges. These were merged into a great National University. Up to the time of the liberation these colleges had been staffed with Japanese professors. Then came the day of repatriation when the places of leadership were taken over by native Koreans. Many of these had been trained in the United States; many more had received their advanced degrees in one of the Japanese imperial universities. But in spite of the divergence of training and the differences in points of view they had one universal passion. That was the desire to know more about science and to be able to apply their findings to the problems of the nascent nation. It is little wonder that there was a growing feeling that the scientists should organize and that they should pool their resources to build a social and an economic order in Korea that would permit that nation to take its rightful place among the nations of the world. Everywhere professors met there was always one topic of conversation. That was atomic energy. Then they would bemoan the fact that for the past six years they had been deprived of the periodical literature and the scientific publications of the remainder of the world.

The library of the Seoul National University is particularly rich in the history and the literature of the Orient. It has been enriched on several occasions by lavish gifts from members of the Korean royal family and from other individuals. The Japanese had subscribed to most of the learned journals of the world. But with 1940 there came an end to all publications. The bound files ended with that date; the newspapers of the world ceased coming; new books were stopped by the war. Then came the days of combat, and the work of

the librarian became that of a warehouseman rather than that of a trained curator of books, papers, and magazines. After the liberation came chaos in the physical plants and the feeling of chaos in the minds of the new leaders. This was the situation in Korea when the American Military Government came into the country.

As soon as college faculties were organized and started to work there were discussions about the necessity for the organization of the scientists of Korea. This was also discussed by those interested in industry, commerce, and government. In fact, several small groups had organized to meet these demands. These new organizations clustered around personalities and within professions. They partook of the political ideology of the leaders and they were more or less mutually exclusive. Science was moving along personal and political lines, and there was a growing feeling of dissatisfaction about the trends. This became more and more evident as the scientists themselves called attention to the inadequacy of the growing practice. Old friendships were beginning to dominate the scene. The scientific specializations were being segregated. The problems of admission to one or another of the groups were being settled on the basis of friendship or political affiliation. Thus was chaos worse confounded.

Last December a small group met at the office of the Department of Education to discuss the whole problem and to seek information about the organization of scientists in the other countries of the world. I was asked to consider the organization of a scientific society in Korea and to write a proposed constitution and a set of by-laws for such an organization. The library of the Seoul National University was a veritable treasure house of materials on the scientific societies of the nations of the civilized world. This literature was canvassed, and out of the study there emerged a form of organization that was adapted to the needs of Korea and was fashioned to meet the psychology of the Koreans.

The final draft of the constitution provided for two organizations. One was the Korean Association for the Advancement of Science, patterned largely after the American Association for the Advancement of Science. Provisions were made for sections of the various sciences and for regional societies. The general administrative patterns were established. The second organization was the Korean Academy of Science. It was planned that this Academy should be the honor society for the proven scientists of the country. Membership was to be determined by the Academy itself after an initial group had been carefully selected by an Activating Committee. Membership in the Academy was limited to fifty or fewer members, to be elected for life. The new members were to be called upon for inaugural addresses in their fields of study and research. These lectures would provide the programs for the annual meetings of the Academy. An Executive Committee was created; its members consist of the President and the Vice-president of the Association, the Chancellor and the Vice-chancellor of the Academy, together with the Secretary General of the two groups.

On January 30, 1947, sixty-two of Korea's leading scientists met to form the Korean Association for the Advancement of Science in a large classroom of the Technical College of Seoul National University. It was a bitterly cold morning; the chilled seekers after knowledge huddled around a small Japanese wood-burning stove in the middle of the room. Occasionally an old, grizzled Korean came noisily into the room and added a few more sticks of precious wood to the fire. In addition, an *hibachi* stood on the presiding officer's desk. This is a large glazed vase, half full of ashes, in the center of which nestle a few embers of glowing

charcoal. The speaker and the presiding officer warmed their hands over these coals when the cold became intolerable. The bright points of fire served as good cigarette lighters, too, for matches are scarce and very costly in Korea.

Amid such scenes the Korean Association for the Advancement of Science and the Korean Academy of Science were born. I had been asked to speak on "Korean Science and Korean Scientists." The address was clearly translated, sentence by sentence, by Dr. Lee Tai Kyn, Dean of the College of Arts and Sciences of the National University. He is an able chemist and a graduate of the Imperial University of Japan. The opening address over, the men proceeded to organize. They elected Dean Lee as the temporary chairman and then the proposed constitution and by-laws were offered. There followed a general discussion, at which time a great number of questions were asked and answers given. The afternoon and most of the next day were spent in translating the document. The constitution and by-laws had been previously submitted to the Department of Justice of Military Government and to a number of interested scientists.

The remainder of the second day was spent in discussing the provisions of the constitution and the by-laws. As the cold night came on the group finally adopted their constitution and their by-laws. Five minor changes had been made in the original proposals.

On February 1, the Activating Committee met in the offices of the Department of Education. They proposed that the two new organizations be accredited by the Department of Education as the two national scientific societies. This plan was according to one of the changes made in the original draft. It was suggested in the proposed constitution that the bodies be chartered by the Legislature, which was then in session. The members reasoned that their procedure would be better since the Department of Education could obtain funds for the operation of the Association and the Academy from legislative appropriations. So, in the presence of the officials of the Department of Education, the accreditation was granted, and the Korean Association for the Advancement of Science and the Korean Academy of Science were sponsored and officially blessed as well as endowed. The Original Copy of the proposed constitution and by-laws has been presented to the American Association for the Advancement of Science for its archives.

Those in charge of the work in Korea will soon begin to correspond with American scientists and with the A.A.A.S. They are ready to undertake the rehabilitation of science in Korea and through this rebirth to bring Korea into a place of leadership in the scientific world.

POPULATIONAL CHARACTERISTICS OF AMERICAN SERVICEMEN IN WORLD WAR II

By MAPHEUS SMITH

Dr. Smith (Ph.D., Vanderbilt, 1931) first came to Washington in 1935, on leave from the University of Kansas, where he had been teaching sociology. He was then Research Analyst, Federal Emergency Relief Administration and Works Progress Administration. During the war he was in the Division of Research and Statistics, Selective Service System. He is now Assistant Chief of Records and Research, Office of Selective Service Records.

SEVERAL groups of specialists are interested in the age, race, occupational and industrial background, educational level, and marital-dependency status of American servicemen in World War II. For example, population specialists are interested in population composition studies of all kinds of groups, both per se, as well as for the light they shed on the present composition of the total population and their implications for future population composition, size, and quality. Industrial manpower specialists are interested in the impact of military mobilization on industrial manpower and productive capacity. Military manpower specialists need to know what effect the drain of mobilization has on the ability of the nation to equip and transport armed forces. They also need to know what further men could have been withdrawn from civilian life for use in the armed forces without weakening the nation's power to support military operations. Sociologists are indirectly concerned with populational characteristics of servicemen for all these reasons, but are more directly interested in the broader implications of the facts. For example, does military service tend to eliminate people with some characteristics more rapidly than others? Or, stated another way, does military service constitute a selective factor on the quality of the population? Sociologists also seek by a study of the effect of occupational selection and selection of men by marital status to gauge the effect of large military mobilization on social institutions and community organization.

The following sections review the available facts on the numbers and populational characteristics of more than 13,000,000 highly selected men, below the grade of commissioned officers, serving in the armed forces of the United States between 1940 and the surrender of Japan in September 1945. The available information is substantially but not entirely complete even for the inducted and enlisted men. Data on the Coast Guard, which was transferred from the Treasury Department to the Navy for the period of active fighting, are lacking, as is much of the information on the Marine Corps. Information on the Navy also does not cover as much of the emergency period as that on the Army. However, information is available on many of the characteristics of more than 95 percent of these men.

Racial distribution. Men of all racial groups composing the American population served in the armed forces, but whites were somewhat overrepresented in comparison with the general population. Race data, available on almost 13,000,000 inducted and enlisted men in the Army and Navy, exclusive of the Marine Corps and Coast Guard, reveal that 8.5 percent were Negroes, and all other races constituted 91.5 percent. Since 9.5 percent of all males eighteen through forty-four years of age in the national population in 1940 were

Negroes, this racial group was underrepresented. Although the percentage variation was small, the number of Negro servicemen was more than 130,000 less than their percentage in the general population would lead one to expect.

The only information available on minor races is on Army inductions. Such information reveals that about 0.5 percent of inducted men were Puerto Ricans, 0.3 percent were American Indians, 0.2 percent were Japanese, 0.2 percent Chinese, 0.1 percent Filipinos, and other races, chiefly Hawaiian and Mexican, were 0.3 percent. These figures agree very closely with those for the general male population eighteen through forty-four years of age. The only exceptions were American Indians, who were underrepresented, and the Chinese, who were overrepresented. The shortage of Indians was probably due to the overage of this group among volunteers, while the Chinese, not being accepted readily as volunteers, were overrepresented among inductions. Failure to accept large numbers of Negroes as volunteers during much of the war also was reflected in the overage of this race in inductions (11.2 percent of Army inductions, 9.5 percent of male population).

Age. As is true of the armed forces in all wars, the American serviceman of World War II was young. Men entering the Army and Navy averaged more than six years younger than all men in the country aged eighteen through forty-four in 1940. Younger men in this age range had entered service in disproportionately larger numbers and older men in disproportionately smaller numbers.

When the fighting ended almost half the men who had served were still under twenty-six years of age, 42.6 percent were between twenty-six and thirty-seven years of age, and 7.5 percent were thirty-eight years of age or over. In contrast, only 29 percent of the total male population were under twenty-six in 1940, 38.2 percent were twenty-six through thirty-seven years of age, and 32.8 percent were thirty-eight years of age or older. The comparative youth of those who entered the armed forces was the inevitable result of the fact that the armed forces restricted the acceptance of men above certain ages and established physical standards for acceptance that few older men could meet.

Analysis by individual year of age reveals that servicemen surpassed the general population in proportion in each group in each year of age from nineteen through thirty-one, but were surpassed in all age groups above thirty-one years.

The age characteristics of inducted and enlisted registrants of the white and Negro groups were generally the same as for the total group, except that Negroes were about half a year younger than whites, on the average. The main reason for this was that Negroes were not accepted in as large numbers during the early period of mobilization, when older men were accepted, as later, when the age range was reduced to obtain more young men for offensive warfare.

Civilian occupations. Manual workers, predominantly from cities, contributed a larger proportion of inducted and enlisted men to the armed forces than they constituted of the 1940 experienced male labor force, whereas professional, managerial, service, and agricultural workers were underrepresented in the ranks. Thirty-nine percent of all inducted and enlisted men reported a civilian occupation as operatives and laborers at a semiskilled or unskilled level at time of entrance into service. This proportion contrasted with only 31 percent in the experienced labor force of 1940. Another 14.2 percent of servicemen were craftsmen, foremen, and kindred workers of highest manual skill,

who constituted only 13 percent of the total experienced labor force in 1940. Servicemen whose civilian occupations were nonclassifiable, largely because they had no definite work experience or skills, constituted 8.1 percent of all servicemen, but only 1.4 percent of such persons were in the male labor force of 1940.

Professional and semiprofessional workers were 3.6 percent of servicemen, 5.2 percent of total male workers; managers and officials were 2.5 percent of servicemen and 7 percent of total male workers; clerks and sales workers were 12.2 percent of servicemen and 13.2 percent of the male labor force; service workers were 4.6 percent of servicemen and 6.4 percent of total workers; and farmers and farm laborers were 10.8 percent of servicemen and 17.8 percent of total male workers. In addition, 4.9 percent reported they were students at entry into service, compared with a number of male students above eighteen years of age in 1940 equivalent to 5 percent of all experienced male workers.

In interpreting these occupational data it is important to recognize that officers are not included, and these are drawn predominantly from among professional, semiprofessional, managerial, official, and clerical workers and students. Selective Service deferment policies also led to the retention of many professional, managerial, and agricultural workers in work necessary to the war effort. The differential for service workers is greatly affected by the large proportion of such men found physically unfit. This factor also affected agricultural workers to some extent.

Civilian industries. Information on the civilian industry of servicemen is much less complete than for occupation, but some general conclusions are possible. During the first year of the war and in comparison with the 1940 experienced male labor force, all industries were underrepresented among Selective Service registrants aged eighteen through thirty-seven years, except government employees and workers in industrial establishments not elsewhere classified. The underrepresentation was proportionately greater among agricultural workers than for any other industry group, and the causes were the same as those mentioned in connection with occupation. The other groups were underrepresented because of the very great differential for workers in establishments not elsewhere classified (16.9 percent for servicemen, only 2.6 percent for the 1940 male labor force). The unemployed were a major factor here, but there were many others whose industry was unclassifiable because of poor reporting.

Other industrial data for men inducted during the period November 1943–December 1944 reveal the effect of changes in the relative availability of different industry groups. In comparison with the 1940 male labor force, agricultural workers were less underrepresented and manufacturing workers were greatly overrepresented.

The distribution of last civilian occupation of servicemen was extremely variable from one industry to another. And this distribution also differed greatly from that of the 1940 male employed population of comparable ages. A considerably larger part of inducted males than of the total male population was from operatives in manufacturing (19.1 percent) and craftsmen in manufacturing (7.1 percent) than was true of the male employed population in 1940 (8.8 and 5.8 percent, respectively). On the other hand, a much smaller proportion of inducted than of total workers were employed as proprietors in all industries, professionals in service industries, craftsmen in construction and service industries, and service workers in service industries. The first three of these differences resulted largely from Selective Service occupational

deferment policies, and the last was greatly affected by the high physical rejection rate of service workers.

Marital status and dependency. As a rule, the armed forces have preferred to restrict their personnel to single men without dependents. This has been particularly true of recruitment for foreign wars and of men who are conscripted, because of the conflict of military life with family interests of married men and men with dependents. This selective policy was followed in World War II as long as possible, but the need for a very large military establishment and the necessity of having young men for combat, regardless of their dependency and marital status, combined to bring about the induction of many married men, fathers, and single men with collateral dependents.

More than 3,000,000 married men did serve among the enlisted and inducted personnel of the armed forces during the war, but they made up only 28 percent of all servicemen, in contrast with the 59 percent of the total male population aged eighteen through forty-four years who were married in 1940. Thus, less than half as large a number of all servicemen than of men in the total population were married.

Information on the proportion of divorced, separated, single, and widowed men is not available for those who served in the Navy, but such data for Army inductions reveal that 69.6 percent were single, 25 percent were married, 2.5 percent were separated, 2.4 percent were divorced, and 0.5 percent were widowed. Since corresponding figures for the total male population of comparable ages were single 38.9 percent, married 56.3 percent, separated 2.9 percent, divorced 1.1 percent, and widowed 0.8 percent, over 70 percent of the Army inductees were men without marriage ties at the time of induction, and 60 percent of all men of the same age were married, separated, or widowed.

The same general differential between the marital status of inducted soldiers and the total population is noted for each age group. The percentage of single men declined progressively from the nineteen-year-old youths (95.9 percent) through age thirty-four (46.4 percent) and age group thirty-five to thirty-nine (44.8 percent), but the difference between the percentage of single men in the service and general population increased steadily with increasing age. For age nineteen the difference was only 1 percent, for age twenty-five it was 26 percent, and for ages thirty-five to thirty-nine it was 29 percent. The percentage of married rose with age for both servicemen and all males; the proportion of married was consistently much lower for servicemen, and the difference increased with age. The percentage of widowed men was consistently smaller for servicemen in each age group than for the total male population, but was higher in the case of the divorced, in both cases increasing with age. In short, the differentials in marital status between servicemen and others increased in all categories with increasing age.

Information on combinations of marital and dependency status of servicemen is confined to Army inductees. A total of 13.7 percent of the unmarried registrants who were single, divorced, or widowed reported dependents at time of entering service (parent, sibling, or other); 61.3 percent were unmarried and without dependents; and 25 percent were married and had dependents. In comparison, only 30 percent of the total male population eighteen through forty-four years of age in 1940 were unmarried and without dependents, 9.4 percent were unmarried but reported dependents on the census schedule, and 60.6 percent were married. Since single men may have believed that they could avoid induction if they reported dependents, it is possible that the proportion of servicemen

who were unmarried with dependents is overstated somewhat. However, since Selective Service policy was to avoid as long as possible the induction of married men with bona fide dependents, it follows that after all eligible single men had been forwarded for induction the unmarried men with dependents would be the next group to go, and married men with dependents would be the last to be called up. Such a sequence of processing toward induction is indicated by the marital-dependency figures on induction and by the differentials between the figures for inducted servicemen and those for the total male population.

Education. World War II servicemen of all classes were above the national average in amount of schooling. A total of 56.8 percent of men inducted or enlisted in the Army and Navy had completed at least one year of high-school work, and 12.3 percent had completed at least one year of college work. The same proportion of the total male population eighteen through forty-four had completed one or more years of college, but only 40.6 percent of the total male population had finished one to four years of high school but less than one year of college. On the average, servicemen had one more year of schooling than the total male population.

The difference between the educational background of men serving in the armed forces and those in the total population was greater than this, however. In the first place, men inducted and enlisted in the Marine Corps and Coast Guard, not included in the data mentioned above, were more highly selected for schooling than the average of Army and Navy servicemen. In the second place, officers of all services are highly selected for educational qualifications. For example, Army officers completed one year of college, compared to one year of high school completed by those below the rank of officers. About 48 percent of the officers had completed one to four years of college, and almost one-sixth more had completed some graduate work.

Both Negro and white servicemen were selected on the basis of educational background. The educational status of white servicemen was above that for Negroes, but both white and Negro servicemen reported more schooling than the total male population of the respective races. Over 74 percent of white soldiers had completed at least one year of high school, compared with 56 percent of the total white male population aged eighteen through forty-four years in 1940. Forty-five percent of Negro servicemen had the same level of schooling, compared with only 21 percent of the total male Negro population of the same age group. Thus, although whites surpassed Negroes in educational status both among servicemen and the total male population, Negro servicemen had more education than the total white male population. Also, the differential between servicemen and total males was greater for Negroes than for whites, revealing a proportionately higher degree of selectivity for Negroes than for whites. Negro servicemen surpassed total Negro males by two school grades, on the average, compared with only one school grade for white servicemen compared with the total white males.

The superiority of educational background of servicemen over the total male population appeared in all age groups, but was somewhat greater among older than younger men. The superiority of servicemen was one school grade for men aged thirty-one to thirty-five and two grades for men thirty-six years of age and over. For youths under twenty-one years 79 percent of servicemen had completed one or more years of high school, compared with 67 percent of total males, and 74 percent of servicemen aged twenty-one to twenty-five years had completed one or more years of

high school, compared with 62 percent of total males.

Physical and mental status. The physical and mental status of servicemen was necessarily far above the average of the general population, since those with certain kinds and degrees of defects were rejected for service. It is true that servicemen were not all perfect physically, and for the greater part of the war period some men were accepted for limited military service. Such men had defects that prevented their use for general military service. The maximum of limited-service men that could be accepted was fixed at 10 percent of men inducted in any induction station on any day. Slightly less than 5 percent of all inducted men were actually below the standards for general military service.

The average inducted man had one recordable defect, which, however, was not of a kind or degree to cause his rejection. The rate for limited-service men was slightly less than two defects per man, compared with slightly less than one for general service inductees. The average rejected man was reported to have about 1.5 recordable defects serious enough in type or degree to be disqualifying.

Information on specific defects reveals some of the effects of military selection on the characteristics of the residual civilian population. The armed forces accepted men with certain defects of eyes, throat, nose, sinus, teeth, mouth, genitalia, feet, and skin, and with varicose veins, venereal disease, and weight deviation. This means that so far as these defects are concerned the civilian and military populations remained quite similar, and military selection did not materially alter the physical status of the total male population. On the other hand, as a result of rejection for any sort of military service, there was an increase in the residual civilian population's average incidence of tuberculosis, hernia, and hemorrhoids, and of ear, lung and pleura, cardiovascular, abdominal viscera, kidney and urinary, musculoskeletal, endocrine, and neurological defects, as well as of the incidence of mental disease and deficiency and infectious and parasitic diseases. The precise amount of effect selective factors had on the civilian population is not known, however, because not all the civilian male population of military age were given physical and mental examinations. Nor has information on the physical characteristics of enlisted men been summarized for comparison with the inducted men and the residual population.

Of those men who were inducted, about 35 percent were without recordable defects, a figure about twice as large as for the total examined and, it is believed, of the total male population of comparable age. All these men without recordable defects were inducted for general military service, whereas all men inducted for limited service had recordable defects, as did all rejected men. In view of the fact that possibly an even larger proportion of men who voluntarily enlisted were without recordable defects, the effect of the transfer of men from the civilian population into the armed forces necessarily greatly lowered the average physical and mental quality of the civilian population, so far as recordable defects indicate that quality.

State of residence. Because of the influence of the Selective Service System, the armed forces were recruited from each state in about the same proportion. Since more than 60 percent of all servicemen were inducted and these men were called from each state in proportion to the number of men already furnished by the state and also in proportion to the total registration of the state, the proportion of all servicemen from each state was approximately the same as the proportion of males of service age in that state. New York, the most populous state,

furnished the largest number of servicemen, followed, in order, by Pennsylvania, Illinois, California, Ohio, and Texas.

A few states furnished a significantly larger proportion of servicemen than they had of Selective Service registrants. The more populous and industrialized states of New York, Pennsylvania, California, Massachusetts, and New Jersey were outstanding in this respect, largely because of the influx of industrial workers from less-industrialized states where their registration records were retained. On the other hand, Alabama, Georgia, North Carolina, South Carolina, and Virginia were underrepresented among servicemen, because of losses through migration and because of high physical rejection rates and large proportions of agricultural workers.

The inevitable effect on the civilian population of the withdrawal of men of military age was to make it overwhelmingly a feminine population, to leave it with a slightly larger proportion of nonwhites than before, to increase its average age and the average age of its males, to bring about the replacement of men in industry with boys, retired workers, women, and girls, to increase the percentage of the civilian male population who were married and who had dependents, and to lower the average educational and physical status of the civilian male population. Military withdrawals did not of themselves materially affect the migration or distribution of the male civilian population, but tended rather to reflect the changes resulting from expanded war industry and the recruitment of workers in parts of the country in which the greatest wartime industrial expansion occurred.

The temporary effect of these changes was great, but the period of military service of most of the servicemen was so short that the permanent effect of these withdrawals on the characteristics of the total population probably will not be very serious. Although casualties were heavy, the rapid demobilization of the armed forces enabled the civilian population to return quickly to its former general characteristics of sex, age, race, marital and dependency status, occupational and industrial characteristics, and educational status. War casualties increased slightly the proportion of the population with disabilities, but this is about the only change that will continue in effect for as much as a generation. The effect on marriage rates of the withdrawal of millions of young single men from civilian to military life is already being substantially erased by a record marriage rate in the early postwar period. The net effect of delayed marriages on the birth rate remains to be assessed, but it now seems likely that there will be no serious permanent effects of the war on the number or composition of the American population.

Book Reviews

TOWARD COSMIC ENERGY

The Evolution of Modern Physics. Carl Trueblood Chase. ix + 203 pp. $2.50. Van Nostrand. New York. 1947.

"HARVARD UNIVERSITY announces that its president will teach a course in 'The Growth of the Experimental Sciences' in the University's new program of General Education." Great news! The scholar-president of a university will teach his undergraduates! The history of science comes into its own! Here and there the world moves forward!

Carl Trueblood Chase has recognized a sound principle for years—"a study of history is essential to a full understanding of the world we live in . . . especially true in the realm of science. . . ." Fifteen years ago he embodied the principle in *A History of Experimental Physics.* In the current year of grace, irradiated, ionized, radioactivated, and fissioned mankind will buy anything labeled "atomic, energetic, and modern." So Dr. Chase and his publishers have brought forth a popular model called *The Evolution of Modern Physics.*

The new model is well planned. Twenty chapters, each an act in a great drama, unfold the story of human knowledge from lodestone and amber days to the contemporary world of neptunium and plutonium, intruding neutrons and splitting atoms, darting photons and spinning electrons, ephemeral positrons and shadowy neutrinos. Each major character in the drama from Thales to Rutherford, and many a minor one, steps upon the stage, addresses his questions to Nature, hears and records her answers, and makes his exit, leaving to successors new knowledge, new concepts, new principles, new speculations, new ways of looking at the same old world. An urge toward unity and simplicity has moved all the great inquirers, and the spirit and trend of his times has prompted each to ask his particular questions at his appointed time. That evolution has been continuous and consistent is convincingly told by Dr. Chase. A reader who knows the outlines of political and social history and the rudiments of chemistry and physics will follow the book with sustained interest and profit.

One wishes that the entire text were written in language commensurate with the story that it tells. The first four chapters are overloaded with detail. Paragraphs become entangled. Sentences are heavy with words. Asides are frequent and often irrelevant. At the end of the fourth chapter the reviewer threw the book aside and turned for refreshment to *The Rise of Modern Physics,* by Henry Crew, a gentleman-scholar of the old school who knows physics and writes its history in terse, lucid, convincing English. Chase's later chapters, however, treat specific and limited developments in modern physics and are much better written. Altogether the book gives a vivid picture of physics during the past sixty years.

Perhaps ten years from now the author will bring his book up to date and will then reconsider his earlier chapters. And there are always available as models the writings of those great English-speaking scientists, those masters of the mother tongue such as Michael Faraday, John Tyndall, and Sir James Jeans.

The book is beautifully illustrated with

twelve full-page plates showing phenomena and equipment representative of modern physics.

THOMAS D. COPE
Randal Morgan Laboratory of Physics
University of Pennsylvania

EASY WRITING'S CURST HARD READING

Writing Scientific Papers and Reports. W. Paul Jones. ix + 115 pp. $2.50. Wm. C. Brown. Dubuque, Iowa. 1946.

THE syllabus prepared by W. Paul Jones, Professor of English in Iowa State College, for use in an undergraduate course, is elementary, detailed, and practical. The author seems to know where young writers (and many older ones) need help.

In the first chapter Professor Jones makes scientific writing seem pretty noble. He says it presents facts, excludes unsupported opinions, does not exaggerate; it is accurate and truthful, disinterested, systematic, sincere; it is not emotive, argumentative, nor persuasive. He is too polite to say that some of it is bunk.

The elementary semantics in the next few chapters will help those who lack experience in writing. The processes of definition, classification, analysis, and description are outlined from the standpoint of one approaching them for the first time. Next come detailed suggestions for writing abstracts, short and long reports, and even book reviews.

To writers past college age, the last two chapters will probably be the most valuable in the book. Chapter XIV, which contains sound advice on abbreviation, punctuation, and like matters, will provide a useful "form sheet," or manual of typographical style, for many minor problems of technical writing. It should help eliminate blunders by the inexperienced and the forgetful. The last chapter treats with clarity and good sense more general topics of sentence structure and diction. Special attention is given to matters in which many writers need guidance—parallelism, antecedents of pronouns, dangling modifiers, wordiness.

Because this classroom syllabus is detailed and has numerous examples and exercises, it should be suitable also for self-instruction. I think that engineers, researchers, and others who try to do technical writing without special training could profit by studying it.

PAUL W. MERRILL
Mount Wilson Observatory
Pasadena, Calif.

THE LITERATURE OF PROPAGANDA

Mass Persuasion: The Social Psychology of a War Bond Drive. Robert K. Merton. 210 pp. $2.75. Harper. New York. 1946.

AN analysis is made of the content and techniques utilized by Kate Smith in a radio war bond drive, together with the results of interviews concerning the broadcast with over a thousand people. Appeals are examined as to themes used and content avoided. Effects on listeners are related to their prevailing states of mind on the kindred subjects of patriotism and war bonds. A brief concluding chapter sums up the implications of the findings from a social point of view.

The results reported in this book are a worth-while addition to the literature of propaganda and are based on an interesting technique for its study. Organization of discussion is not always clear, and many of the sectional headings are confusing or even misleading. On the whole, however, the book should prove interesting and useful to students of public opinion, as well as to others interested in its implications.

R. B. AMMONS
Department of Psychology
University of Denver

PROGRESS AND POVERTY

Trinidad Village. Melville J. Herskovits and Frances S. Herskovits. vii + 315 + xxv pp. $4.75. Knopf. New York. 1947.

THIS book should have a wide audience among scientists and laymen interested in better understanding the nature of culture and culture change in general, and of Negro culture in particular. The authors are a well-known team of American anthropologists who have had considerable firsthand experience in studying Negro culture in Africa, South America, the Caribbean, and the United States. One of their major interests has been the study of the diffusion of African culture and the modifications it has undergone in various parts of the New World.

This book, based upon one summer's field work in 1939, gives us the first systematic description and analysis of the culture of a rural Negro community in the English-speaking portion of the Caribbean. The setting of the book is the village of Toco in the far northeastern part of the island of Trinidad. The authors describe the village structure, the problems of making a living, the marriage customs, family life, magic, and religion. The final chapter deals with an analysis of the retentions and reinterpretations of African customs and beliefs in Toco.

The description of the village of Toco reveals a picture of poverty and backwardness characteristic of colonial peoples almost everywhere. The village has no electric lights, no running water, no sewage system. Most of the people live close to a bare subsistence level, earning their living from a combination of gardening, fishing, hunting, and seasonal labor on nearby cocoa and copra plantations. Less than half the families own their own land. There is practically no self-government, and political control is in the hands of whites who represent the British government.

In Toco, as in other Negro communities of the New World, women play a very important role in the social, economic, and religious life of the community. The authors are careful to explain that this is not simply a direct carry-over of African tradition, but rather a consequence of the unequal effect of slavery upon the lives of men and women. In the breakdown of native African culture during slavery, those institutions in which men were paramount, such as the patrilineal sibs and the complex political and governmental structure, were smashed. But women retained much of their traditional importance in family life and the rearing of children. It was, therefore, the women who played the key role in the transmission of the African cultural heritage.

Among the many interesting examples given by the authors of the survival and reinterpretation of African customs and beliefs are the following: the persistence of African food and eating habits; a form of cooperative labor among the men known as *gayap;* the belief that irate ancestors will punish abortion by barrenness; the importance of divination and the role played by the spirits of the dead; obtaining the approval of the ancestors for marriages.

> Toco culture corroborates the findings of New World Negro cultures everywhere that Africanisms have persisted more in the religious life of the people than in any other, save only folklore and music which were favored by the indifference of the slave-owner to their continuing expression. [The authors describe the cult of the Shouters in great detail and show that] . . . this sect represents a point of transition between African religion represented in Trinidad by the Shango cult, and undiluted European forms of worship, as found in the Church of England, among the Moravians, and to a lesser extent, the Seventh Day Adventists and the Baptists.

Despite the persistence of Africanisms, the Negroes of Trinidad, like those of our South, are not especially concerned with the question of the African origin of their culture. They have a passionate desire to

achieve the higher standard of living of the whites and look to education as one of the principal means of improving their situation. Many an illiterate Negro makes sacrifices that his children may learn to read and write.

OSCAR LEWIS

Department of Sociology and Anthropology
Washington University

NATURALISTS OBSERVE—

The Mammals of Virginia. John Wendell Bailey. xvi + 416 pp. Illus. $5.00. Williams Printing. Richmond, Va. 1946.

Mammals of California. Lloyd Glenn Ingles. xix + 258 pp. Illus. $4.00. Stanford. Stanford University, Calif. 1947.

Mammals of Eastern Asia. C. H. H. Tate. xiv + 366 pp. Illus. $4.00. Macmillan. New York. 1947.

THIS painstaking, well-written account, illustrated with photographs and drawings, of the one hundred and thirty different mammals living in Virginia, including domesticated ones and a list of the fossils, is the result of many years' study and observation on the part of its author, a professor and head of the Department of Biology in the University of Virginia.

The general description of the Commonwealth of Virginia and its life regions, with a history of the published studies of Virginia mammals, amounts to a short monograph on the state itself, with much historical material. A classified list of the mammals is followed by a key to the families, and then for each species is given a diagnostic description, its distribution in the state, and its habits when known.

Even the different races of humans are classified and a population census given for each. There is a chapter on the economic importance of the various mammals, one on conservation, and a short chapter on the geological history, illustrated with a time chart. There is an extensive bibliography and a good index.

This thoroughly comprehensive and interesting work will be of much value to laymen, students, and naturalists.

WILLIAM M. MANN

National Zoological Park
Washington, D. C.

NO EQUIVALENT area in the world has at the same time so diverse a mammalian fauna and so complete a documentation of it in the form of specimens and published literature as has the state of California. The very magnitude of the task seems to have discouraged two generations of mammalogists from organizing the readily available data into a much-needed comprehensive treatise on the mammals of that state. It is certain, therefore, that the appearance now of a book entitled *Mammals of California* will attract the immediate attention of most American mammalogists.

Those who expect to find here a precise, detailed, and thoroughly documented work similar to Hall's recent *Mammals of Nevada* will be disappointed, but to the large body of amateur naturalists, teachers of biology in high schools and junior colleges, and beginning students of mammalogy this book should be a most welcome contribution. By arbitrarily eliminating all details of taxonomy and geographic distribution as well as all citations to published sources of information, the author has achieved a readable and unencumbered series of descriptive accounts of representative species of Californian mammals. Unfortunately, this same process of simplification has produced an appearance of superficiality, which does an injustice to Dr. Ingles' knowledge of his subject.

The book is essentially a compilation; those who are already familiar with the literature will recognize and know the sources of most of the distribution maps and

many of the items of natural history that are incorporated into the accounts. The author's original contributions, which, in view of his considerable field experience, must be numerous, are anonymously buried in the mass of compiled data. It seems unfortunate that a book professing to be written for the benefit of beginners in the field of mammalogy should fail to have even a condensed bibliography that would guide students into more advanced phases of the science.

Subspecies and all the problems of intraspecific geographic variation, which play so prominent a part in most studies of Western mammals, are strictly avoided. The ultimate unit in this book is the species. Keys based on geographic range, habitat, size, and similar superficial characters are provided for all the species of land mammals. A representative species in each genus is alloted a descriptive natural-history account. Among the bats, however, one species is allowed to represent the entire order; the popular appeal of bats to the amateur mammalogist seems to have been badly underestimated. The very cursory treatment of cetaceans is more readily understandable in a book of this sort. A tabular list of the species of Californian mammals provides a more balanced picture of the fauna, but here the taxonomically backward genera, such as *Dipodomys* with fourteen species, seem to overwhelm the more thoroughly worked ones, such as *Thomomys* with only four. A brief description of the process of preparing study skins is a commendable feature.

The half-tone reproductions are by far the most valuable part of the book. Most of them are from photographs made by the author, of living animals, and they give ample evidence of Dr. Ingles' skill as a photographer of mammals. The portraits of even such familiar subjects as black-tailed deer are a pleasure to study because of their arresting freshness and clarity of detail. The line drawings in general are inferior, and they include at least two incredible errors: kangaroo rat tracks are shown with five, instead of four, toe marks for each hind foot; and an asserted gray fox skull was obviously drawn from a red fox model.

As an attractively arranged guide for beginners, this book excels any other that has been published on the mammals of the Pacific Coast states. Those who attempt to use it as a manual or source book will be baffled by the extreme censorship of technical detail.

DAVID H. JOHNSON
United States National Museum
Washington, D. C.

THIS book is one of the "Pacific World Series" being published under the auspices of the American Committee for International Wild Life Protection and representing a thoroughly praiseworthy objective—to make readily available reliable information concerning the natural history of the vast Pacific region, which as a result of the war has definitely "come up in the world" in popular interest. Thus far the series has included works on Pacific mammals, insects, reptiles, plants, fishes and shells, and native peoples, as well as a book on *The Pacific World* in general. The geographical scope of the present number "covers some 6,000 miles of the Pacific coast of Asia, from northeastern Siberia through Manchuria, China, Burma and Indo-China, to the Malay Peninsula. The mammals of Sakhalin, Japan, and Formosa are included."

Dr. Tate's book is aimed at the reader who wants general facts rather than technical matters of mammalogy—the G. I., for instance, who wonders what that little animal was that he saw along the Burma Road. Scientific lingo is kept to the minimum, though Latin names had to be used for proper identification. Following two

short discussions, one defining what a mammal is and the other summarizing the geographical features and faunal areas of eastern Asia, the book takes up the various mammals group by group and species by species in systematic order (beginning with the insectivores and ending with the odd-toed ungulates). The larger groups (orders, families, and subfamilies) are characterized briefly, followed by the descriptions of the various species and forms. The descriptions average about half a page each and include distinguishing characteristics, details of size, color, etc., some idea of the range and habitat, and the animal's relation to other members of its group. The accounts seem well condensed and adequate for purposes of this book. Seventy-nine line drawings, including three maps, illustrate the text.

Since this is a volume of the handbook type, and hence likely to receive long, hard reference usage, it is a pity that the publishers were so skimpy in its manufacture. The binding is cheap and flimsy, inferior to that of many a dollar reprint; and the book is priced at $4.00! It seems to me that the hard and exact work put into the contents of this volume by Dr. Tate and his associates at the American Museum deserves a finer and more durable encasement.

PAUL H. OEHSER
Smithsonian Institution
Washington, D. C.

GLADLY WOLDE HE LERNE, AND GLADLY TECHE

On Understanding Science. James B. Conant. xv + 146 pp. Illus. $2.00. Yale. New Haven. 1947.

THIS little volume is an interesting, and probably important, trial balloon, dealing with the problem of "how we can in our colleges give a better understanding of science to those of our graduates who are to be lawyers, writers, teachers, politicians, public servants, and businessmen" (p. 1). Dr. Conant thinks that this can be achieved most effectively and economically by a lecture course in the history of science. Such a demonstration lecture course was given at Yale University by Dr. Conant. The present volume represents the illustrative material of these lectures. The four chapters, or lectures, deal with the scientific education of laymen; illustrations of scientific advances from the seventeenth century "touching the spring of the air;" illustrations from the eighteenth century concerning electricity and combustion; and certain principles of the tactics and strategy of science, that is, a more specific discussion of *the universal scientific method.* The reader will note that all the examples selected to illustrate scientific procedures and scientific discoveries are from the physical science fields. In any course on the history of scientific discovery and scientific advance, the selection of illustrative examples will, of course, vary with the teacher's own special field and special competence. Every field of science provides classical examples.

Such lecture courses in the history of science, such books on well-selected epics of scientific discoveries, will interest all informed adult citizens, scientists and nonscientists. The "$64 question" before us is just this: *Can such lecture courses or such books adequately impart the scientific method to people with no more factual contact with science?* Being a real scientist, Dr. Conant is not dogmatic on this point. He says (p. 17): "What I propose represents a tremendous extrapolation from any educational experiments of which I am aware. . . . I may be peddling a rope of sand." We shall not have the answer till we make the controlled experiment. On the basis of my own experience and observations, I believe that a minimum core of individual laboratory or field work is necessary for an implantation of the scientific method in the human grain,

an implantation that will effectively contribute to the person's understanding, thinking, and behavior. In my humble opinion, anything less than that may interest and amuse laymen, but it will not significantly reduce the present scientific illiteracy.

A. J. CARLSON

Department of Physiology
The University of Chicago

REMEMBRANCE OF THINGS PAST

Fragments of Entomological History. Part II. Herbert Osborn. vii+233 pp. Illus. $2.75. Spahr & Glenn. Columbus, Ohio. 1946.

THE subject matter of this little volume, as its title indicates, is highly fragmentary and informal in character. It is presented by its author as supplementary to a volume bearing the same title published in 1937. The contents of this and of the previous volume were written bit by bit over a period of several years, and both were published largely as originally written, without full rechecking, or bringing all data down to date of publication. The author is a well-known dean of American entomology, now in his ninety-first year, who has long since attained world-wide distinction in his chosen field as scientist and educator.

As would be expected, the subject subdivisions of this second volume consist largely of a continuation of the same kind of material and of the same type of treatment as given in the earlier book. It comprises further consideration of the development of Federal, state, and commercial organizations in insect research and control, college instruction in entomology, entomological societies and congresses, periodical publications, journals of societies, and entomological books and monographs published during the past decade. A considerable portion of the book is devoted to highly informal sketches, old letters, and reminiscences of a biographical character concerning past fellow-workers and living colleagues. Because of the author's acquaintance with many of them, this portion of the work possesses particular interest.

Consideration also has been given to various commemorative events and memorials over the years, notably the Seventy-fifth Anniversary of the Entomological Society of Ontario, the Thomas Say monument, the Rafinesque Memorial, and the Anniversary Meeting for the half-century of the American Association of Economic Entomologists. Appropriate attention also has been given to growth and development of present-day buildings and equipment for entomological work, and to spraying, dusting, and fumigation appliances and the status of the insecticide industry.

During his long career the author of this book trained many of today's leaders in economic entomology, and they with his many other students and colleagues over the years hold for him a veneration, loyalty, and affection so unusual—so nearly unique in character—that it becomes a matter of extreme difficulty for any of his contemporaries, as in the present instance, to attempt critically or impersonally to evaluate any productions of his authorship.

J. S. WADE

Bureau of Entomology and Plant Quarantine
U.S.D.A., Washington, D. C.

MOST PUNCTUAL MIRACLE

Spring in Washington. Louis J. Halle, Jr. 227 pp. Illus. $3.75. Sloane Associates. New York. 1947.

TOO few of the thousands of government bees who swarm, at the appointed times, in and out of their stone hives along Constitution Avenue ever see, much less understand, the events taking place in the natural world about them. Mr. Halle is not one of these. Although a busy assistant division chief in the complicated business of running the United States government,

he finds time to escape from the stuffy doings of the hive to ride his bicycle down the long straight pathway of Hains Point. Using his coat as a sail, free before the wind like the swooping gulls about him, he pedals back in the teeth of a brisk March wind, with lungs and eyes refreshed for a day's work.

Another morning Halle cycles down Rock Creek Parkway by starlight to Potomac Parkway, south along the Potomac River to Lincoln Memorial Bridge, across to Virginia through the early morning mists, and then southward again along Memorial Highway to Roaches Run lagoon, where, as the sun rises, the distinctive markings of each species of waterfowl become visible. The myriad phases of the oncoming dawn are his to enjoy, and he describes them beautifully in his book, with many appropriate allusions to the classics.

On certain mornings, when the feel of spring is particularly strong in the air, the cyclist pursues his pedaling with more energy than usual and finds himself speeding ever southward as if to meet the northward rushing spring and its wave of bird migrants. At Dyke, well down the Potomac beyond Alexandria, on the way to Mount Vernon, the electrifying song of the first warbler of the year halts him in mid-stride. Only the initiated know that quickening of the pulse the arrival of the gaudy, restless, migrant warblers produces in a bird-watcher. It is all the stimulus needed to pour new energy into tired muscles and drive the observer on to possibly new and unexpected finds. The author responds to these stimuli like the real naturalist he is, and the cold, muddy March waters of the Dyke marshes do not deter him as he wades knee-deep through them, his mind absorbed with the excitement of the sight of wheeling teal and yellowlegs above his head and the bittern that bursts from the reeds beneath his feet.

Halle is one of those who rebel at man's continual effort to harness and formalize nature and bend natural processes to his will. He gets spiritual satisfaction from the thought that, although the forces of nature may be guided temporarily by man, they are never diverted from their ultimate purpose. Like the tiny wild violet he saw springing up in a crack in the pavement, nature is ever alert to find an opening in the armor of artificiality. As if knowing that civilizations are always temporary, she waits patiently for an opportunity to throw her shock troops into any breach, eventually reclaiming the land from man with wave after wave of ecological succession. Halle takes pride in exposure of his body to the chill winds and icy waters of early spring; in satisfying his thirst when and where he pleases, even with swamp water, like the Indian or the fox; in being able to live in harmony with the irresistible forces of nature. This adaptability to the natural environment gives him an exhilarating sense of freedom from the regimentation of the human hive.

Yes, any Washington naturalist would admit after reading Halle's book that the author is one of the fraternity. His observations are keen, and his interpretations are intelligent, anchored to the firm foundation of a good knowledge of the literature. An occasional lapse, such as considering the sedentary, permanent-resident red-bellied woodpecker as one of the early migrants into Washington, together with the towhee, which actually is a migrant (although some few individuals winter here), is not serious. Such slight misinterpretations of his observations are certainly excusable in view of the complexity of the subject. Halle has given us a delightfully written and remarkably accurate description and interpretation of the natural surroundings of our legislators and other national leaders and the capital's teeming hordes of clerical workers. The charming black-and-white sketches by Francis L. Jaques of scenes well known and

beloved by Washingtonians add greatly to the enjoyment of the book.

JOHN W. ALDRICH
U. S. Fish and Wildlife Service
Washington, D. C.

FROM MURMANSK TO VLADIVOSTOK

The U. S. S. R., A Geographical Survey. James S. Gregory and D. W. Shave. 636 pp. Illus. $4.25. Wiley. New York. 1946.

THE Soviet Union occupies one-sixth of the land surface of the globe and, with the exception of the British Empire, which does not constitute a single continuous mass of land, is the largest state in the world.... When it is realized that the U. S. S. R. produces more peat, sugar beets, flax [one might add also wheat, rye, oats, and barley], manganese, locomotives, railway-wagons, and agricultural machinery than any other state in the world, and more oil, machinery, agricultural machinery, motor lorries, tractors, iron and copper ore, gold, and superphosphates than any country in Europe, as well as occupying a high place in the output of coal, electricity, iron, steel, chemicals, and cotton, it is obvious that the last twenty-five years have seen the transformation of a formerly backward agrarian country into one of the world's leading industrial nations.... More significant than the phenomenal growth of industry, however, is its geographical redistribution.... The Soviet Union has added to the revived and reconstructed industrial centres of European Russia a powerful new industrial axis which extends eastward from the Urals, through Western Siberia and Irkutsk to Komsomolsk, Khabarovsk, and Vladivostok.... It must be remembered, however, that the output *per head of population,* of agricultural and industrial products had not reached that of the U. S. A. and Great Britain in 1939.

The above quotations from the last chapter indicate something of the flavor of this book and of the strength and importance of the Soviet Union.

This work provides the most detailed and up-to-date factual background on the geography of the Soviet Union available in English. About half the space is devoted to the systematic treatment of the terrain, climate, soils, natural vegetation, historical development, nationalities, agricultural and industrial development, transportation, trade, and population of the Soviet Union as a whole and its place as a world power. The other half is devoted to a consideration of the score or so major regions of the Union; this regional part is particularly valuable as the most extensive treatment of the regions of the U. S. S. R. available in any of the Western European languages.

The book is strong in its detailed recent information based largely on original Russian sources not readily available in this country, its 72 helpful maps and diagrams, and its surprisingly full index, which facilitates checking information on little-known places.

The book is poor in its treatment of place names, which are variously and sometimes quite erroneously spelled; since the American printing was reproduced photographically from the English edition, it was not possible to improve the book in this regard. Some readers will doubtless feel that the book moves too quickly into detailed description without sufficient introductory material, sufficient high-lighting of the more significant features of the land and the people, or an adequate critical appraisal of the relative success of the various Soviet programs for developing and transforming the country into a major industrial and military power with a planned economy.

CHAUNCY D. HARRIS
Department of Geography
The University of Chicago

TIME WAS OF THE ESSENCE

German Research in World War II. Leslie E. Simon. xi + 218 pp. Illus. $4.00. Wiley. New York. 1947.

WHEN considered in the light of present-day threats of cutbacks in funds to continue research of military nature, this book is very timely. It is unfortunate, however, that the author did not extend the scope of the book by col-

laboration with scientists in other fields so that his title would be truly descriptive of the content.

The most serious omissions are in the fields of electronics, including radar, beacon, remote control countermeasures, etc., nuclear physics and the atomic bomb, and chemistry, which fields are not mentioned except in a few cases where demanded by their direct relation to ordnance.

Considerable space is devoted to an attempt to clear up the "currently ill-defined" terminology of research that is likely to leave the reader confused, especially with regard to "basic" research and "pure" research. Furthermore, throughout the book the author never quite makes clear whether he is at the moment speaking of research in general, military research, or the more restricted category of strictly ordnance research. He states in the foreword that he is going to "judge coldly" the completed experiments of German weapons research and, again, he assures the reader that he does not intend to compare the scientific accomplishments of Germany and the United States. However, he repeatedly inserts a soothing statement to the effect that the United States was doing, or did, equal or better work on almost every point.

It is true that Germany was not so advanced on radar (particularly microwave) and the atomic bomb as the United States, but it is also true that this can be attributed to the small amount of emphasis permitted on these projects. Colonel Simon has a tendency to underrate the magnitude of the German war research and its accomplishments. The work on guided missiles was vastly more extensive than, and well in advance of, similar work in the United States during the same period. This tendency to underrate the threat implied in the tremendous scale of German military research somewhat weakens the justifiable argument in the closing chapter, where the author emphasizes the importance of research for national defense during peace in order to accumulate a fund of knowledge to improve the quality of development during war, which inevitably forces more development and less research.

The summary of the more important ordnance research and development in interior and terminal ballistics, exterior ballistics and fire control, aerodynamics, and instruments and measurement techniques is well written and should prove interesting both to the scientist and the general public. An excellent organizational description of German war research agencies, together with a valuable analysis of the conduct of ordnance research, is presented. The author points out the lack of coordination between research and the military, which weakness in the German system greatly reduced the effectiveness of the research program.

CARL HARRISON SMITH, JR.
Naval Research Laboratory
Washington, D. C.

WARTIME NECESSITY

Buna Rubber. The Birth of an Industry. Frank A. Howard. xii + 307 pp. $3.75. Van Nostrand. New York. 1947.

THE current active discussion regarding the future of the American synthetic rubber industry makes particularly timely any book which throws light on the origin of that industry. As principal executive between 1919 and 1945 in the subsidiary of the Standard Oil Company (N. J.) engaged in research and development, Mr. Howard was an active participant in most of the events leading to the establishment of the government-owned industry set up in 1942 and 1943 to supply America's desperately needed rubber requirements. In this book Mr. Howard describes his part in these

events in straightforward historical fashion, maintaining a highly objective attitude and documenting many of his statements in a 52-page appendix of contracts, letters, and memoranda.

The book opens with a detailed description of the relations between the German I.G.Farbenindustrie and the Standard Oil Company, initiated in 1926 and continued until the time of the Hague agreements of September 1939. The titles of some of the chapters indicate the events covered: The Munitions Board, Europe Falls, The Advisory Commission, The Problem Comes to R.F.C., Indecision, Laying the Foundations, Establishing Industrial Cooperation, Setting the War Program, Controversy, Confusion (one of the best chapters), The Baruch Committee, and The Rubber Director. The detailed treatment ends in 1943 as the plants began to come into production.

Our relative inability to take effective action toward synthetic rubber production in the critical years 1940–41 was in line with much of the spirit of the times. One important factor, for example, was the unwillingness of both industrial firms and the government to assume the necessary financial risks. The goal of production was cut by steps from 100,000 tons down to about 2,500 tons and finally brought back to about 40,000 tons. There was an unexplained period of complete inaction from January to May 1941. A limited amount of promised government support for large-scale butadiene production was cancelled as late as September 1941. The necessary impetus to definite decisions and cooperative effort was supplied by Pearl Harbor and our entrance into the war. After that time the program moved along rapidly.

Anyone concerned with synthetic rubber can gain from this well-written and interesting book an excellent insight into the origin of the industry. With the enactment of legislation for a permanent national rubber policy now on the agenda of Congress, its members might profitably consider the future implications of the events described by Mr. Howard.

LAWRENCE A. WOOD
National Bureau of Standards
Washington, D.C.

RIVALING THE SILKWORM

The New Fibers. Joseph V. Sherman and Signe Lidfelt Sherman. x + 534 pp. Illus. $5.00. Van Nostrand. New York. 1946.

THIS book is a valuable contribution in that it brings together in one place information dealing with textile applications of many of the newer resins, both synthetic and semisynthetic. The first 374 pages consist of a detailed discussion of the various types of synthetic fibers now manufactured. The remainder is devoted to a bibliography of American patents in this field.

After a brief introduction, an important chapter compares significant physical properties of the better-known synthetic and semisynthetic fibers. Photomicrographs illustrate differences among nylon, "Vinyon," "Aralac," viscose rayon, acetate rayon, and "Fortisan." Specific gravity, tenacity, extensibility, recovery on unloading, stiffness, toughness, and several other physical properties are discussed. An interesting table of prices is included. Subsequent chapters are devoted to detailed consideration of the development, chemical nature, properties and applications of nylon, Vinyon, polyvinylidene chloride, "Fiberglas," polyethylene, various protein fibers, and the different types of rayon.

A number of materials that are at the present time only in the developmental stage are also mentioned. The discussion of protein fibers is particularly valuable and covers not only casein and soybean protein, but also fibers made from peanut protein,

zein, and chicken feathers. The chapter on new cellulosic fibers includes a review of Fortisan as well as of other less well-known materials.

To find a book whose preface is dated September 1946 bearing notations about elastic nylon, "Vinyon N," "Fiber A," and polytetrafluoroethylene fibers is gratifying and indicates the extent to which the authors have gone to make it up to date. It is also noteworthy that, among the 174 literature references given at the end of the various chapters of the text proper, only one is dated earlier than 1940.

A very interesting chapter deals with the economic aspects of rayon, now second only to cotton in commercial importance. New industrial uses of rayon, especially in tire fabrics, consumption of rayon by trades, price and production statistics for rayon made by the various processes, tables of production capacity by company, plant locations, consumption of cellulose according to type, and discussion of the effect of rayon on the demand for cotton, wool, and silk, paint a striking picture of the position of rayon in the economic life of the nation today. As a logical conclusion to this discussion export markets are considered.

A brief chapter deals with chemical treatments of textiles. The information in this chapter is of interest as far as it goes. It is perhaps unfortunate that emphasis has been placed almost entirely on resin treatments. This field is of course of great importance and is becoming increasingly significant. The fact should not be overlooked, however, that many nonresinous chemicals are used in large volumes in the finishing of textiles to give them numerous specific effects. It is to be hoped that a new edition of this book may see an expansion of this chapter to include other textile-finishing agents which, although less widely advertised than some of the resins, have nonetheless been developed during the past ten or fifteen years and are of vital importance to the textile industry today.

The authors have done an excellent piece of work in presenting a readable discussion of their subject, which should prove of value to the research worker. Much of it should also appeal to those laymen who possess a smattering of technical knowledge. Although the book bears some evidence of hasty assembly, this appears to be an almost necessary corollary of its valuable aspect of up-to-the-minute evaluation of recent fiber technology. Such criticism is hardly justifiable if too great emphasis is not laid on the word "fully" in the publisher's enthusiastic statement that it "describes fully the research efforts now being carried on to develop both . . . manmade fibers and the chemically improved natural fibers."

Both the authors and the publishers are to be congratulated on the very satisfactory make-up and pleasing appearance of this volume.

REGINALD L. WAKEMAN
Onyx Oil & Chemical Company
Jersey City, N. J.

Comments and Criticisms

ON THE NATURE OF ENTITIES

In the February *1947* issue of SM there appeared an article by Mr. Thomson King, entitled "On Life as a Separate Entity." Without wishing to subject Mr. King to unnecessary abuse, nevertheless I shall undertake to point out certain forms of logical confusion in his argument.

The fact of the matter is that not all questions are meaningful. Thus, if you should ask, "What time is it on the sun?" I would reply, "The question is meaningless." In effect, this is to say that things as they are may not be described in the terms used.

Before we can seriously consider any hypothesis whatsoever, we must show that we have not mistaken the form of Indo-European grammar for the structure of the universe. It does not happen—the common-sense belief to the contrary notwithstanding—that we observe, then think, then express our ideas. As Sapir puts it: "... the 'real world' is to a large extent built up on the language habits of the group. We see and hear and otherwise experience very largely as we do because the language habits of our community predispose certain choices of interpretation." We do not see things as they are, but through a form of representation. And if our system of concepts is unsuited to our problems, there is no possibility that these problems will be solved.

Fortunately, it is not difficult to ascertain whether a given system is adequate. Any logicomathematical system whatever specifies a set of elements and a set of symbolic operations. Such systems in and of themselves have no necessary application to the empirical world. We can at will construct an indefinite number of logical systems as well as an indefinite number of mathematics. Hence, it is unreasonable to assert that any sort of logical manipulation can in itself demonstrate or refute an empirical proposition. But if we have at hand things as they are, it is no great matter to compare them with a suggested system and thus perceive the existence or absence of correspondence in structure.

Thus, when someone asserts that life is a separate entity, we would ask (as politely as possible) what he means by "entity," what he means by "life," and whether he asserts that the epsilon relationship exists.

If—as in the case of Mr. King—he is unable to specify the necessary and sufficient conditions for membership in the classes he purports to establish, we say that he has failed to attach a meaning to his terms. After the manner of Wittgenstein, we show this lack of meaning in a simple way. Concerning the symbol "life," on Mr. King's list of attributes, the virus both has life and does not have life. As we have shown, when we find a thing that does not fit into our system of concepts, the system is without question inadequate. In such a case it becomes possible to formulate a *verbal* contradiction in the old system, which can be shown to be no contradiction in the new. (The classical example of this situation is the explanation of the "contradiction" between the Michelson-Morley experiment and the constant velocity of light.)

The meaninglessness of the term entity is even clearer. Mr. King has asserted that by "reason" he has proved that there must be either two or three entities in the entire universe. If we ask what he means by entity, he says clearly: "By entity we mean something having reality in fact, which is separate and unique in itself." Thus, we have six entities: . . . . . . and the proof of Mr. King is shown to be untenable.

The reader may consider that we jest, but we do not. Does not each one of these dots have reality in fact? Is not each one separate? Is not each one unique in itself? Then, on the definition of Mr. King, they are entities, and his proof must be illogical.

We can also show this directly by means of formal logic. Postulating the applicability of the two-valued logic, we consider the two hypotheses of which he asserts one must be true:

A: There are two entities, matter and life.

B: There are three entities: matter, life, and energy.

Formally:

1) "Either A or B but not both" is a tautology if, and only if, A is "not B."

2) A is not "not B."

3) Therefore "either A or B but not both" may be false. Thus it is obvious enough that there may be any number of entities and that we have worked no logical miracle in producing six of them.

The attention of the reader is drawn to the manner of approach. If we had sought to show that Mr. King was in error by the abstract manipulation of symbols, we should have found ourselves forced to abstractions of higher and higher order. But by taking a simple case to which the defined terms

apply, we can in short order show that the subject is talking nonsense.

DONALD B. CREECY, JR.

Annapolis, Md.

IS LIFE A DREAM?

Far below the level of mind, where Mr. King finds it hard to imagine that the addition of life to matter-energy has not introduced something qualitatively different, we may detect the beginnings of the marvelous transformation that takes place when lifeless matter becomes alive. It is the transformation from passivity to activity, from indifference to interest; in short, with the birth of life comes also the birth of values.

What a living thing does is good or bad; and, if it does not do right, it ceases to live. Furthermore, it evaluates its environment; it chooses what it will have, whether of matter or energy, and rejects the other. We may say that the amoeba has conduct; we could never say that of a stone. It has an object in life—to fill the world with amoebae—and it pursues that object.

We may even say that the "primordial protoplasma globule" that first received the spark of life, immediately upon that endowment, began to seek truth. A change occurred in its environment. That change was of moment to it. It called for a reaction. Unless that reaction was correct, true to the meaning of the change, a wrong adjustment would be made. We possess the truth when we foresee consequences.

Since it would be only nonsense to speak of lifeless things in this way, it seems to me Mr. King is on firm ground; but, of course, the mechanists call for proof, and we haven't got it. Who can measure life?

RUDOLPH H. KLAUDER

Ocean City, N. J.

NOTA BENE

My deepest gratitude for, and appreciation of, your interest in high-school students. Participation in the activities of the A.A.A.S. is a supreme joy and of the highest inspiration to a young person who is interested in science.

I attended the Richmond meeting of the Association in 1938 at the age of fifteen, upon the kind invitation of Dr. Herbert Zim, and became a member of the Association and a subscriber to THE SCIENTIFIC MONTHLY a few weeks later. I can assure you it was a great thrill and stimulus.

HERBERT SCHWARZ, JR.

New York City

TO A *COPRINUS*

ON ACCIDENTALLY KICKING ONE OVER
(With Apologies to Robert Burns)

Wee modest flower of the dung
Whose virtues yet remain unsung—
Like all things living, old or young,
Or low or high,
Thou art from Nature's bosom sprung
To live and die.

In every alley, road, or lane
Where equine excrement has lain
Thou rearest up thy shaggy mane—
A noble sight
To charm the scientific brain
With rare delight.

Let none condemn thy low degree
Or habits of coprophily;
For were it not for such as thee
The myriad dead
Would fill the earth from sea to sea
Still undecayed.

If Psalliota's *lustrous fame*
Or Amanita's *evil name*
Are equally beyond thy claim—
The fates have set
Apart for thee a higher aim
And nobler yet.

For thou hast yielded mysteries
To scientists from learned Fries
To Buller, Kniep, and Vandendries,
Whose brains and wills
Sought laws of sex and spore release
Behind thy gills.

Thou hast made dry and scarious
Professors joy-delirious
Who found that sexes various
Existed in
Coprinus fimetarius
Instead of twin.

O fungus of the shaggy tress,
Of gills that slowly deliquesce—
When Man has sought eternal cess?
Thou wilt remain
To liquidate the dreary mess
Left in his train.

THORVALDUR JOHNSON

Winnipeg, Man.
Canada

Technological Notes

Almost Automatic. Only those who have read proof know how maddening it is to try to find all the typographical errors, how certain some are to show up in the finished work. The new calculating machines prevent slips of that kind in presenting the results; the coded answers are printed by machine and then put directly into tables by photo-offset processes. About the ultimate seems to be the compilation of star data as reported by Dr. W. J. Eckert, who, besides being director of the Thomas J. Watson Laboratory of Columbia, is an astronomer of note. Photographs and punched cards covering each star go into the machine, and thousands of pages of tables, free from error, finally emerge.

Long View, Short View. Sometimes we wonder how much effort is wasted in attempts to hang onto every possibility, no matter how inefficient it may be, if over-all planning is successful. For example, there's $150,000 just spent on research to improve guayule and other plants to give us at least *some* natural rubber "in event of another emergency." Surely, our planners will be able to keep the future from getting down to that level. What we need, in a balanced peacetime program according to 1947 estimates of use, is about a million tons of rubber, slightly over half of it natural. We can never attain that supply without importing from countries that need to sell to us.

Plastics Everywhere. A release about plastic bottle caps and seals seems natural enough; the material is plumped up in water before being put in place, and it shrinks to a tight fit. Plastics in oil well drilling seem a little less plausible, but the explanation is simple: a thermosetting coat inside the well casing protects the metal against corrosion as the pipe goes through "hot spots" of corrosive salt water.

Safe Speed. Strictly for laboratory purposes, an airfoil device on a test automobile compensates for centrifugal force and enables tires to be tested at 90 miles an hour on a circular track. Any proposals to add such auxiliaries to ordinary cars had better be resisted. A report on Pennsylvania Turnpike accidents shows that many drivers are unable to handle vehicles at speeds now possible. The report concludes pessimistically that the human element is still the weakest factor in the safe-driving combination.

Average Irishman. An article in the *Population Bulletin* suggests Eire as an example to other nations, if war is to be avoided. That part of the Emerald Isle, scene of the Potato Famine a hundred years ago when the population was 6.5 million, is now a country of 3 million, the richest per capita in Europe. Emigration and late marriages are cited as reasons; Eire is now "mature," but not senile. The suggestion is attractive, but probably fraught with difficulties, especially in view of the recent announcement that the "average American" is an Irishman.

Quinine Back Home. United Fruit Company, famous for its banana boats, is paying attention to another indigenous crop of Central and South America: cinchona bark. The original trees, like the rubber tree, were exploited in their native habitat and only came into flourishing cultivation in the Orient. Now, plantations and research in the Americas show promise with plants of high alkaloid content.—M. W.

The Brownstone Tower

FEW professional scientists dependent on their own earnings are able to attain the ideal life of unrestricted, full-time research. Too often that paradise, glimpsed by a graduate student or research fellow, recedes as he grows older, and the work that he wanted to do is never done. A scientist is rarely paid for doing as he pleases, and perfect freedom for the satisfaction of scientific curiosity is available only in spare time. A scientist employed in full-time research is properly expected to work toward the solution of practical problems assigned to him or proposed by him. To the extent that he is permitted to pursue his work without distractions he will derive satisfaction from it second only to that arising from unrestricted research. He can be diverted from his primary work in many ways: he can be required to write an excessive number of reports, attend committee meetings, criticize manuscripts, answer inquiries, take inventories, prepare and defend budgets, and do many other things that are incidental to productive research. In short, if he is successful in research, clerical or administrative work will creep up on him like quicksand unless he is vigilantly noncooperative.

Such is the prospect to be faced by a young man who chooses to be a government scientist. If he is productive, he is most likely to reach the highest professional grades by giving up personal research for administration. There is no doubt that administrators of research should be men who have demonstrated their own capacity for research. On the other hand, all the cream of research talent should not be skimmed off into administration as fast as it appears. The whole purpose of a research organization is to produce new and useful information, and the best results can be obtained by encouraging men of demonstrated talent to remain in personal research, aided by a suitable number of assistants. This can best be done by offering to producers salaries at least equal to those of administrators, and this is the surest way to break down the prevalent notion that an administrator is superior to, and more valuable than, a producer. In my opinion creative talent is less common and consequently more valuable than administrative competence. The administrator should be the protector of producers, defending their research, getting the equipment and facilities they need, guarding them against annoying interruptions, reducing to a minimum every task that interferes with their research, and facilitating the publication of their results.

The article by Arthur S. Flemming, "Scientists and the Civil Service," in the June issue of the SM shows that the Civil Service Commission is moving in the right direction to obtain better scientists for government service and to make the conditions of their employment more attractive. But Commissioner Flemming, while proposing higher salaries and other benefits, failed to suggest that the highest salaries should be as readily attainable for research as for administration. This is now possible under the law, but in practice equality of remuneration is the exception rather than the rule. I think that no other reform could do so much to make government employment attractive to the ablest scientists.

F. L. CAMPBELL

THE SCIENTIFIC MONTHLY

VOL. LXV October 1947 NO. 4

THE PROGRESS OF SUGAR RESEARCH

By ROBERT C. HOCKETT

Dr. Hockett (Ph.D , Ohio State, 1929) is on a five-year leave of absence from Massachusetts Institute of Technology to carry on his work as Scientific Director of the Sugar Research Foundation, a nonprofit organization with offices at 52 Wall Street, New York City. He has been a Fellow of the National Research Council, Associate Technologist on the staff of the U S P H S , Lecturer of the Swiss-American Foundation for Scientific Exchange, and Chairman, Division of Sugar Chemistry and Technology, American Chemical Society He has published many research papers on the chemistry of sugars.

AN EVENT of exceptional significance for the progress of carbohydrate chemistry occurred in June 1943 when the producers and processors of cane and beet sugar supplying the United States market established the Sugar Research Foundation.

Although the organization is little more than three years old and many of its projects have been underway for less than two years, it may be profitable at this point to examine the accomplishments of the organization and perhaps indicate the course its future development will take.

As directed in the Certificate of Incorporation, the Foundation has devoted itself to a strictly scientific study of sugar with two primary objectives: to develop a better understanding of the role of sugar in human metabolism, and to explore the basic chemistry of the sugar molecule so that its potential industrial usefulness may be more fully realized. It is not concerned with sugar production and supplies or with legal and marketing problems

The Foundation's purposes as outlined in the Certificate are as follows:

> To initiate, promote, assist, develop, maintain, conduct, and carry on, directly or indirectly, investigations, studies, and research relating to sugar, and any and all uses or possible uses of sugar, in any form whatsoever, and whether as a food or an ingredient of foods or beverages, or in industry or otherwise, including, without limiting the generality of the foregoing, the place and value of sugar in the human diet, its relationship to other foods, and its nutritional, dietary, industrial and other uses, purposes or effects, whether separately, or as an ingredient of or in combination or conjunction with other foods or substances.

This broad statement of purposes has been interpreted to include relevant studies in the numerous practical arts and technologies such as baking, preserving, confectionery, ice-cream manufacture, fruit-freezing, pharmacy, metallurgy, tanning, and the like; the investigation of by-products from the beet and cane plants; and also fundamental investigations in the scientific fields of nutrition, biochemistry, physiology, microbiology, and organic chemistry.

It has been the policy of the Foundation to provide for such studies by grants-in-aid to experts already well established in colleges, universities, and research institutes. Applications are received until April 1 of each year for consideration in relation to the fiscal year beginning on the following July 1. In general, grants have been planned to provide increased assistance for special projects in laboratories where guidance and direction, general facilities, and research tradition already exist. It is to be noted in particular that the Foundation employs very few persons directly. The experts who receive grants for the assistance of their research have been expected themselves to employ such personnel as they need for efficient prosecution of the tasks assumed. At the present time fifty projects have been supported, involving more than seven hundred thousand dollars.

M.I.T. laboratory. One of the organization's first undertakings was the establishment at the Massachusetts Institute of Technology of the Sugar Research Foundation Laboratory. Coordinated with the Department of Chemistry curriculum, advanced courses in carbohydrate chemistry are offered to graduate students. Under the direction of resident researchers, and with the assistance of full-time graduate specialists and part-time doctoral candidates, a five-year program has been laid out directed to exploratory and fundamental studies from which new uses for sugar as a chemical material may develop. A system of graduate fellowships makes possible the appointment each year of several research assistants from among the outstanding graduates of colleges and universities who wish to pursue graduate work in the field of carbohydrate chemistry. Such appointees, if they qualify as candidates for the doctor's degree according to the usual standards of the Massachusetts Institute of Technology, and if they maintain their standing, can generally be reappointed often enough to provide support for the entire graduate course. This plan is designed to help maintain the supply of trained carbohydrate chemists available to the sugar and allied industries.

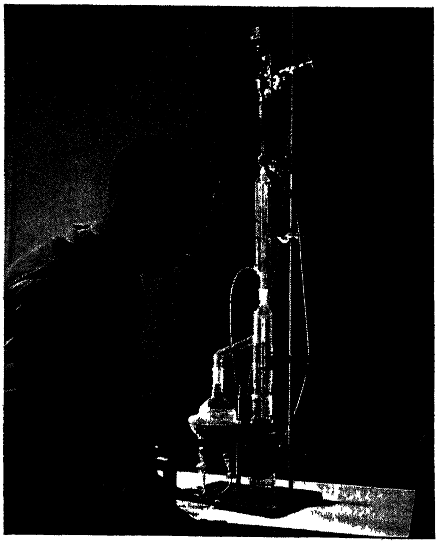


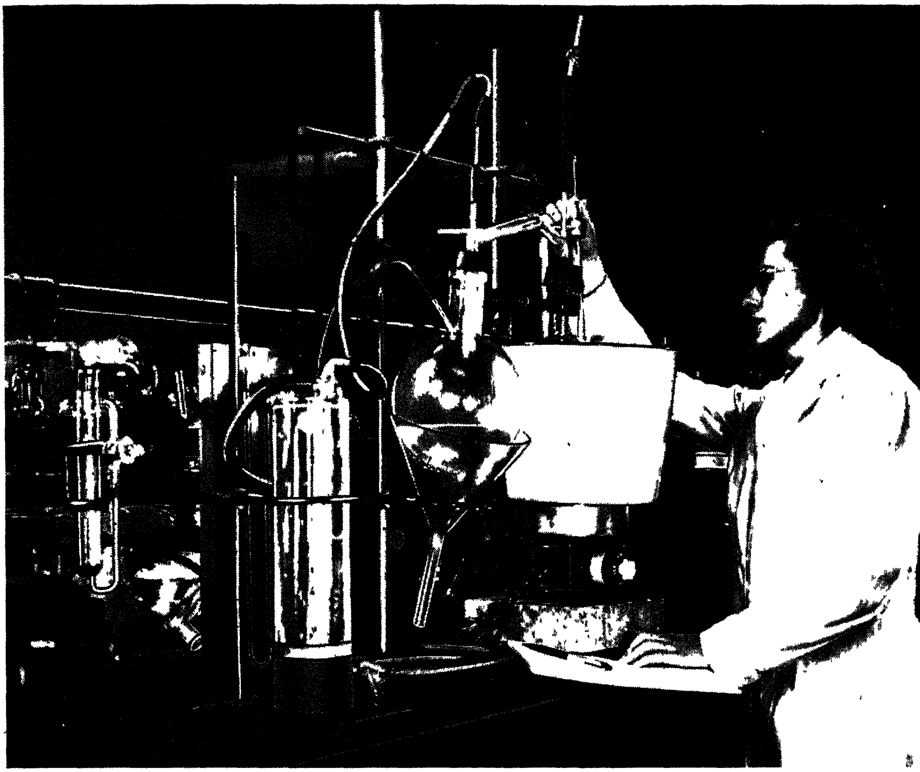
Photo by Arnold Morrison

LABORATORY RESEARCH

A MOTOR-DRIVEN SEPARATOR HAS PROVED VALUABLE FOR STUDYING SUGAR SEPARATIONS AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

Among the developments that are of some practical interest are considerable progress in the selective oxidation of invert sugar and the separation of sugars and sugar derivatives by two-phase liquid solvent extraction. Alcoholysis of sucrose has been studied as a basis for separating dextrose and levulose. Analytical methods based on lead tetraacetate have been further developed, and this substance has been made a powerful research tool. Dr. Lawrence Heidt has attained new efficiency in the control of sugar inversion, and the sterilization of such solutions by heat has been achieved without detectable decomposition.

Physiological studies. A notable volume of work has come out of the first project, that directed by Dr. Ancel Keys, of the Laboratory of Physiological Hygiene at the University of Minnesota, partially supported by



LABORATORY TECHNIQUE AT M.I.T.

MINIATURE VERSIONS OF SUGAR REFINERY VACUUM PANS ARE USED TO PROCESS SUGAR COMPOUNDS UNDER REDUCED AIR PRESSURE AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

the Foundation. The purpose of Dr. Keys has been to study the metabolism in man of sugar and other related carbohydrates, with special reference to the use, digestion, and combustion of such carbohydrates as a source of energy for human work and activity, and to the requirements of vitamins, particularly thiamine and other members of the B complex, as affected by sugar and other related carbohydrates.

Seven research papers, to which some contribution has been made by the Foundation, have been published to date. One of the most significant—"Human Starvation and Its Consequences"—appeared in the *Journal of the American Dietetic Association.*

In recent years, there has been a great deal of discussion about dietary deficiencies, especially deficiencies of vitamins, minerals, and amino acids. Numerous workers have been engaged in experiments concerning the effects of such deficiencies and in describing the various symptoms and diseases that result from them.

On the other hand, very little accurate scientific work has been reported on the effects and symptoms of calorie deficiencies, in spite of the fact that many dietary surveys in recent years have shown calorie deficiencies to be widespread among the population. Because of the tremendous number of people all over the world who are suffering from insufficient food supplies, the effects of calorie deficiencies have assumed vital importance.

When it became apparent early in the course of the war that malnutrition and starvation would be inevitable, Dr. Keys

ANCEL KEYS

HE HAS USED HUMAN SUBJECTS AT THE UNIVERSITY OF MINNESOTA FOR INVESTIGATING THE VALUE OF HIGH-CALORIE DIETS IN THE REHABILITATION OF FAMISHED AND UNDERNOURISHED PEOPLE.

concentrated on the problem of calorie deficiency to discover the most effective means of rehabilitation. A search of the literature showed very little record of what happens to muscles and organs under conditions of starvation. Using volunteer conscientious objectors rather than laboratory animals to expedite the study, Dr. Keys allowed the subjects to eat only what was served to them from the laboratory kitchens. The food was carefully weighed and imitated closely the European diet. Nutritionally, this diet was not too bad, for it consisted of turnips, coarse cereals, and potatoes, with small amounts of meat, fish, cheese, or eggs, supplying a fairly good quantity of the vitamins and essential protein. Its chief deficiency was in food energy, that is, calories, so that the subjects lost approximately 25 percent of their weight. At every stage of the six months' period, tests were made.

The effects of calorie deficiencies were marked. Muscles shrank and the men became too weak to exercise. The heart decreased in size, and the rate of beat dropped to as low as one-half the normal. Sensitivity to cold was noted, and the men complained of feeling depressed and worried. At the same time intelligence, memory, reasoning power, and the function of the senses were unimpaired. Careful examinations revealed no signs of vitamin deficiency. For recovery it was found that calories were of prime importance. Various kinds of amino acid concentrates failed to speed up rate of recovery, nor were the effects of large doses of vitamins noticeable. Intravenous feeding not only failed to help but was actually dangerous because of the added strain on weakened hearts.

During the first few weeks 3,000 calories a day were needed. Later, 3,500–4,000 calories a day for several months resulted in marked improvement. Even with extra calories, however, recovery was slow, with only 80 percent recovery attained after six months of special feeding.

Thiamine requirements. Another phase of Dr. Keys's investigations has increased our knowledge of the human requirement for Vitamin B_1, thiamine. It was this vitamin that caused a considerable flurry of excitement several years ago when it was found that American diets do not contain much more thiamine than the Oriental diets that often cause beriberi. Some concern arose as to whether Americans generally were not on the fringe of deficiency, and several authorities urged a move to replace refined carbohydrates in part by those containing thiamine.

Accumulating evidence has changed the picture considerably. First, as compared with the Orientals, we are heavy fat consumers, and fat does not require thiamine for its combustion to the extent that carbohydrates do. Second, Orientals eat a great deal of fish, much of it raw, and raw fish has been found to contain an antimetabolite that spe-

cifically destroys thiamine. Hence, as compared with the Orientals, we need less thiamine and lose less through destruction. With respect to determining the requirement, Dr. Keys has made a most significant contribution. As a result of all these observations, the National Research Council has revised downward its Recommended Daily Allowance for thiamine. The new figure, which contains a liberal margin of safety for normal persons, represents a daily intake not difficult to attain by selecting a generally good diet in which sugar need not be restricted specifically.

It does not follow that new foods high in thiamine would not be a valuable and welcome addition to American diets. One of the most promising new foods of this class is edible yeast. The Foundation is taking an increasing interest in yeasts, since they can be produced from by-product molasses and are capable of providing needed protein and B-complex vitamins for our diets. The study of edible yeasts has only begun, and there is a distinct possibility of finding strains with higher vitamin content, better flavor, and superior protein.

Dr. Keys has also confirmed the older claims that carbohydrate is somewhat more rapidly effective as an energy source than fat or protein. He has disproved the claim that sugar, in reasonable concentrations, delays the emptying of the stomach and has shown that high-carbohydrate meals are just as "lasting" as meals of other types. The last finding is contrary to the claims that led to wide propaganda for high-protein breakfasts.

This last question has formed the subject of extensive studies by Dr. John Haldi, of Emory University. Using large numbers of healthy young medical students, he has given high-carbohydrate breakfasts alternately with high-protein breakfasts but has found no mid-morning hypoglycemia following either type, either when sedentary occupations are pursued or when severe exercise is undertaken. He concludes that hypoglycemias are the result of disturbed metabolism rather than of diet. Related experiments upon the efficiency of factory workers are now underway.

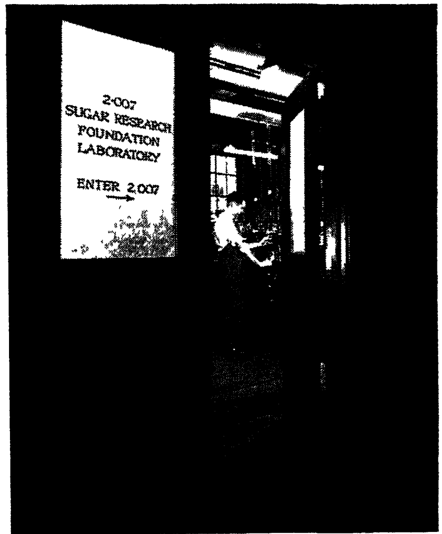


Photo by Arnold Morrison

SUGAR CHEMISTRY AT M.I.T.

WHOLLY CHEMICAL STUDIES OF SUGAR AND SUGAR DERIVATIVES, COORDINATED WITH ADVANCED COURSES IN CARBOHYDRATE CHEMISTRY, ARE BEING CARRIED ON UNDER A FIVE-YEAR PROGRAM AT M.I.T.

Dramatic discoveries have been reported by Dr. I. M. Rabinowitch, of the Montreal General Hospital, who has observed the actual speed at which sugars taken by mouth reach the blood stream. Although sucrose taken by mouth must be inverted, or hydrolyzed, in the body during the course of absorption, it actually provides glucose to the blood stream more rapidly than does dextrose, as such, taken by mouth, even though this simpler sugar has often been considered capable of direct absorption "without digestion." Moreover, sucrose has a characteristic and specific effect upon the inorganic blood phosphate, which tends to emphasize the individuality of familiar sugar and to show that it cannot be regarded as a mere mixture of *d*-glucose (dextrose) and *d*-fructose (levulose). This work has shown

again the desirability of pressing investigations into the metabolism of sucrose, or ordinary sugar.

Dr. Rachmiel Levine, of Michael Reese Hospital, Chicago, has studied the metabolism of levulose specifically and has shown that it is used directly by many tissues, particularly by the liver, which removes *d*-fructose from the blood two and one-half times as fast as dextrose. For the entrance of fructose into the tissues, insulin appears to be unnecessary, though once glycogen has been formed the normal utilization of this reserve carbohydrate does require the agency of insulin. A new test for liver function based upon the response to fructose injection has been developed.

Dental research. The problem of tooth decay requires a tremendous intensification of research effort if the factors contributing to susceptibility and resistance are to be understood and controlled effectively. Leading public health authorities recognize both the importance and the great complexity of this problem and emphasize the importance of broadening the basis of caries research.

Photo by Arnold Morrison

DENTAL RESEARCH

A STUDY OF METHODS FOR REDUCING THE INCIDENCE OF CARIES IN CHILDREN BY TOPICAL APPLICATIONS OF SODIUM FLUORIDE SOLUTIONS IS BEING CARRIED OUT AT TUFTS COLLEGE DENTAL SCHOOL UNDER DR. BASIL G. BIBBY AND HIS COLLABORATORS.

Although the contribution that can be made to dental caries research by the Sugar Research Foundation is necessarily very small, the hope has been expressed that it may have an importance out of proportion to its monetary value as an example that may encourage other agencies to give attention to this field of study.

Particular attention has been given to the selection of projects for support in order that the limited funds available for this field may be as valuable and effective as possible. Many studies of caries have been invalidated by a lack of attention to statistical method or by the use of inadequate numbers of subjects. Others have been impaired by the use of short cuts such as the measurement of "indirect indices of caries activity" instead of the direct measurement of the cavities actually formed in animals under specific regimens. The projects aided by the Foundation employ no such indirect indices, since these introduce, at the least, an element of doubt and of possible controversy. The methods of investigation approved by the Foundation by appropriation of grants-in-aid are of the relatively slow and expensive type, but they provide the best promise of sound progress in the long run.

To detect significant differences in the caries incidence rate within a group of individuals subjected to special conditions, it is necessary to know the extent of the variations that might have occurred if they were left alone. Dr. Julian D. Boyd has made very careful studies of the caries records of Iowa children for over two years in order to determine this degree of natural variability. He was equally concerned to find an institutionalized group of children who could be subjected to complete dietary control without errors, exceptions, or accidents. Such a group has finally been found, and a comprehensive experiment is getting underway to show whether truly superior diets containing

adequate protein, vitamin D, fluoride, and other factors will give caries control without specific relation to the level of sugar consumption.

A team of well-qualified experts has been assembled at the Harvard School of Dental Medicine. Colonies of cotton rats, hamsters, and monkeys have been established, and systematic studies of the factors affecting caries have been begun. One study relates specifically to raw sugar as compared with refined. Preliminary reports show no significant difference in the animals fed the two types of sugar. This finding, if confirmed, tends to show that there is no specific inhibitory factor in raw sugar and also that caries is not a simple calcium deficiency.

A great contribution from the Harvard staff is completion of a critical survey of the medical literature on the relation between diets and caries. This survey is designed to show which results reported to date are reliable and to indicate what conclusions regarding caries may be considered as established. This review is to become part of a comprehensive analysis of the literature on dental caries research that is being compiled under the auspices of the National Research Council.

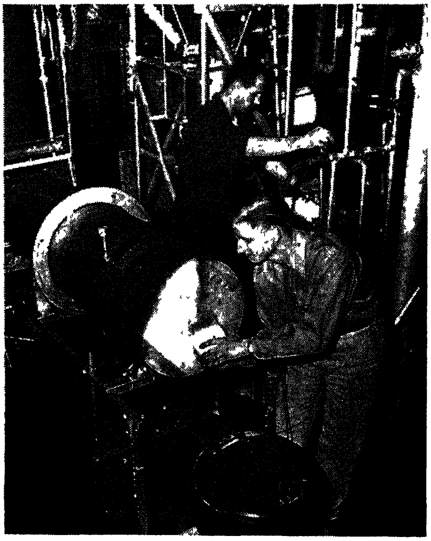
Experiments investigating the effectiveness of restoring normal fluoride content of children's teeth by the topical application of fluoride solutions are promising. Under Dr. Basil G. Bibby, of Tufts College Dental School, and his collaborators, noticeable reductions in the caries incidence among treated children have been observed.

Levulose extraction. In the field of applied

Photo by Arnold Morrison

DIETARY STUDIES ON COTTON RATS

A TEAM OF SPECIALISTS AT THE HARVARD SCHOOL OF DENTAL MEDICINE HAS BEEN STUDYING THE EFFECTS OF DIET ON COMPOSITION OF TEETH AND INCIDENCE OF CARIES IN COLONIES OF COTTON RATS.



A PILOT PLANT
EXTRACTING LEVULOSE FROM SUCROSE AT THE ENGINEERING EXPERIMENT STATION OF THE UNIVERSITY OF COLORADO TO MAKE THIS HITHERTO SCARCE CHEMICAL AVAILABLE FOR RESEARCH.

research, levulose, the simple sugar of high sweetness, is now becoming available for the first time in sufficient quantities for experimental work by physicians, physiologists, biochemists, and others, through the project supervised by Dr. Carl W. Borgmann and Mr. M. M. Reynolds, of the Engineering Experiment Station at the University of Colorado. The pilot plant, which has been in production for some time, uses an ion-exchange process to obtain levulose from common sugar and represents the only commercially feasible method in actual operation. Satisfactory yields of levulose have also been obtained from beet molasses.

Although levulose, often referred to as fructose, or fruit sugar, is an important natural sugar with many potential uses in food industries, there has never been enough of it for extensive study because of the high cost and difficulty of separating it by traditional methods. The method used in the pilot plant now in operation is relatively cheap and simple. Another advantage of this process is that it achieves a true separation without destroying the dextrose fraction. Studies are being made to estimate costs and technical problems involved in actual manufacture on a large scale.

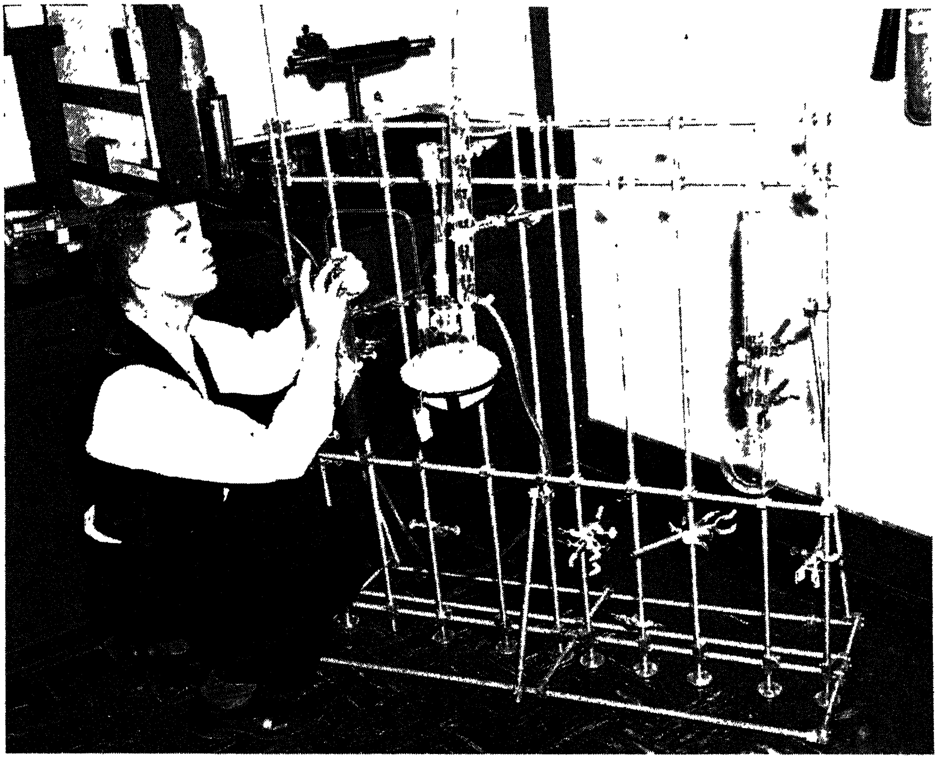
In addition to its high sweetness, levulose has a higher solubility than either sugar or dextrose. Recent research also suggests that it may have unique and important physiological effects. Lack of availability in the past has hindered research, but studies are now being carried on to find out more about the storage of levulose in the body, its use by various organs, and its effect on blood lactic acid.

It is known that levulose is absorbed and stored by the liver at two and a half times the rate of dextrose. In the liver it is transformed into glycogen and, as such, provides readily available blood sugar reserves. Glycogen also appears to have a protective action, possibly preventing cirrhosis and guarding the liver against toxic agents.

Levulose also evidently plays an important but unknown role in early life. English investigators have recently discovered that 90 percent of the blood sugar of embryonic lambs consists of levulose and that this sugar occurs in seminal fluid.

Industrial projects. There is another development that promises to be of commercial value. In the Eastern Regional Laboratory of the U. S. Department of Agriculture, Drs. Nichols and Yanovsky have considerably extended the investigation of the allyl ethers of carbohydrates. Such ethers were reported as long ago as 1923 by Tomecho and Adams, but they now appear much more interesting because of the availability of allyl chloride upon a large scale.

Allyl sucrose when unpolymerized can be dissolved in organic solvents such as alcohol, chloroform, acetone, benzene, or toluene. If applied to a surface such as wood, metal, or paper, the solvent will evaporate to leave a smooth coating of high gloss. Heat treatments produce a coating resistant to all known solvents, hot oils, and reasonably



J. W. LeMAISTRE IN HIS LABORATORY
HE SUPERVISES A PROJECT AT THE INDUSTRIAL RESEARCH INSTITUTE OF THE UNIVERSITY OF CHATTANOOGA ON INDUSTRIAL USES FOR SUGAR AND SUGAR PRODUCTS.

concentrated acids and alkalies. These coatings are said to withstand temperatures up to 400° F. The Sugar Research Foundation has recently concluded an agreement with the Department of Agriculture under which we have placed a Research Fellow of our own selection at the Eastern Regional Laboratory to concentrate upon further study of these coatings. A number of improvements have already been worked out under this cooperative study. Methods for "bodying" allyl sucrose to favorable brushing consistency have been perfected, and a spontaneously drying product that requires no heat curing has been developed. It is hoped that pilot-plant operations will make samples generally available within six months.

New frozen fruit products using sugar have been described by Dr. W. V. Cruess, of the University of California. With his colleagues he has also studied the blanching of fruits in isotonic sugar solutions and the syrup concentrations best suited to the preservation of color, flavor, and soluble nutrients in various types of fruits.

The fractionation of molasses has made progress under Drs. F. W. Zerban and Louis Sattler, of the New York Sugar Trade Laboratory, as well as under Dr. Wolfrom and his associates at Ohio State University where new chromatographic adsorption methods for separating sugar acetates have been developed. At the University of Utah, glucose mercaptals have been obtained in pure crystalline form by using both sugar and molasses as the starting materials.

Dr. Carl Neuberg, of New York University, has perfected a method for speeding up

the fermentation of sugaı to glycerin from 5–7 days to 14–18 hours and is engaged at present in a similar study of molasses.

Drs. Andrew Van Hook and Elizabeth Roboz at the University of Wyoming have prepared light-colored pectins from dried beet pulp and have produced *l*-arabinose and galacturonic acid salts from the same material. The use of ion-exchange resins for de-ashing pectin is being studied. Dr. Van Hook has continued studies on the kinetics of sugar crystallization from real and synthetic massecuites and has shown the independence of crystallization rates from diffusion and viscosity. The effects of natural impurities on crystallization are being studied.

It is expected that findings from a number of other projects will soon reach the publication stage, and that with the termination of some of these studies other projects under consideration for some time can be initiated.

Award program. To supplement its own coordinated program of research through grants-in-aid, the Foundation has stimulated research and inquiry into sugar by establishing a series of prizes in recognition of outstanding discoveries or the development of original knowledge about sucrose. These awards, administered by the National Science Fund of the National Academy of Sciences, are open to scientists of all countries. Four intermediate annual awards of $5,000 and a Grand Award of $25,000, to be given in 1950 for the most important disclosure in the preceding five-year period, have been

MICE ARE USED FOR VITAMIN STUDIES

IN THE DEPARTMENT OF PHYSIOLOGICAL CHEMISTRY OF THE YALE UNIVERSITY MEDICAL SCHOOL SURVEYS HAVE BEEN MADE OF THE VITAMIN CONTENT OF VARIOUS NEW PRODUCTS OF THE SUGAR INDUSTRY.

announced. The first award of $5,000 was shared by Drs. W. Z. Hassid, H. S. Barker, and M. Doudoroff, of the University of California, Berkeley, for the enzymatic synthesis of crystalline sucrose, published in 1944.

The discovery of a method by which crystalline sugar can be synthesized enzymatically is significant, not because of commercial possibilities for increasing sugar supplies—for it has none—but because of its scientific implications. Its disclosures of a method of sugar synthesis through the action of living organisms, and also the details of the reversal of this action, that is, the breakdown of sugar into its simpler components, are both important. Most significant of all is the fact that this new synthesis renders possible new experimental approaches to the problem of sugar metabolism.

For a long time enzymes have been known that can cause the sugar molecule to combine with water and to break it down into its simple components, dextrose and levulose. Many enzymes work in reverse, but until now the familiar sugar-splitting enzymes had never been observed to bring about a recombination of dextrose and levulose into sugar. Now by means of an enzyme elaborated by *Pseudomonas saccarophila* sugar has been obtained for the first time directly from dextrose phosphate and levulose.

The very common and easy splitting of sugar into dextrose and levulose has led most plant and animal physiologists to think of sugar as little more than a loose combination of the two simpler hexoses, dextrose and levulose. They have not been greatly concerned with sucrose, as such, because it has been expected that sucrose would show little unique or individual behavior but would break down under almost any ordinary physiological environment into the simpler hexoses and then act just like a mixture of the two. Consequently, both plant and animal physiologists have been inclined to study dextrose rather than sucrose in connection with physiological problems.

The lack of commercial availability of levulose has caused this half of the sucrose molecule to be relatively neglected even though, as half of sucrose, such an omission obviously constitutes a serious hiatus in the complete study of sucrose metabolism.

However, the problem does not reduce so simply to a mere study of the two breakdown sugars, for levulose, as the free sugar, occurs largely as a relatively stable 6-membered ring compound (the pyranose form), whereas it is definitely proved by the organic chemists that in sucrose it occurs combined as a less stable, and probably more reactive, 5-membered ring form (the furanose form). This form has not been isolated in a free state. There is every reason to expect that this active form, when liberated from the sucrose molecule by enzymatic action, might give very different and yet very fundamental physiological reactions that could not be obtained through the use of simple mixtures of invert sugar (since the latter consists of free dextrose and *free* levulose). It is also possible that the dextrose half of the sucrose molecule, when first liberated from sucrose, may be in a more reactive state than its normal condition in free dextrose. There is not, however, as clear-cut evidence to indicate such a difference for dextrose as there is for levulose.

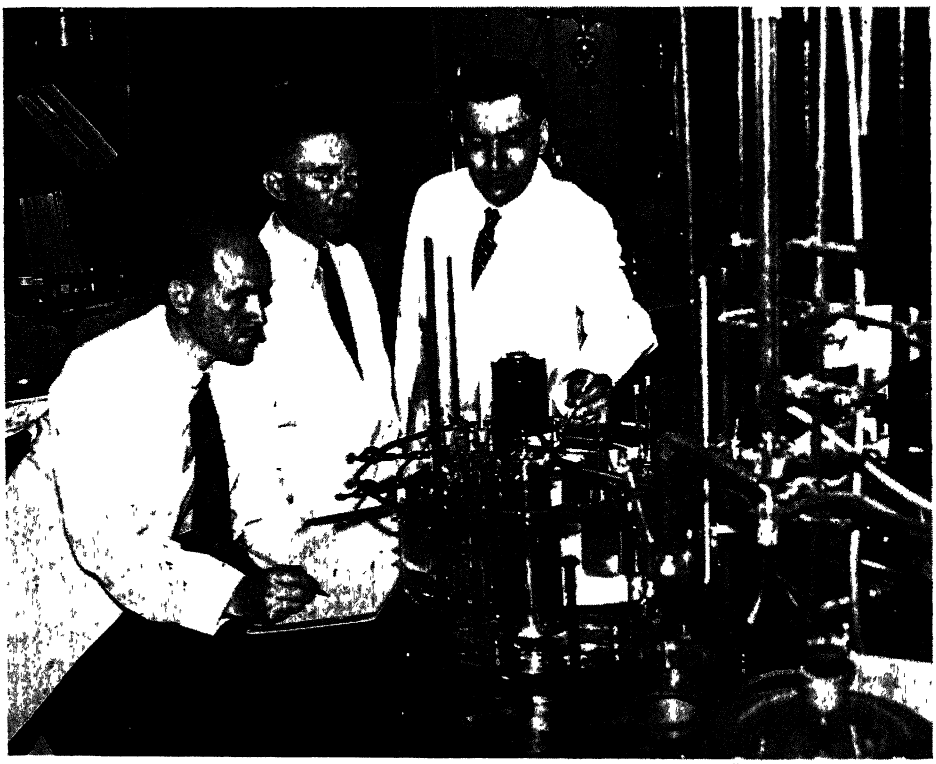
The net result of these facts and a consideration of the bond energy in the link between the two simple sugars in sucrose is that it is not justifiable to assume, as has been generally done in the past, that the behavior of sucrose in human metabolism can be successfully studied by observing mixtures of dextrose and levulose, that is, invert sugar, or that the behavior of either half of the sucrose molecule can necessarily be predicted by the study of either dextrose or levulose individually.

In order to determine what actually happens to the two sucrose fragments in the body, it is necessary to observe the behavior of these individual fragments during the

course of human metabolism. But, since either fragment may be converted to glycogen (blood sugar), via partially unknown mechanisms, it has not been possible to distinguish adequately one fragment from the other in their final utilization.

Using "tracer" technique, with dextrose or levulose prepared synthetically to obtain an atom per molecule of one of the carbon isotopes, it will be possible to follow the metabolism of these compounds through the various human organs. As pointed out above, however, results so obtained would *not* necessarily or even likely be expected to be identical with the behavior in the body of the two individual halves of the sucrose molecule. The only way to ascertain definitely the behavior of the fragments of the sucrose molecule in vivo would be to use "tagged" atoms in first one and then the other half of the molecule. But to do this, and to know in which half of the molecule the tagged atoms are located, would require the synthesis of sucrose from tagged dextrose or levulose of known origin; that is, it would be necessary to know which one contained the tagged atoms.

Hassid, Doudoroff, and Barker have actually made two important contributions. The first is the synthesis of sucrose; the second, which also serves to emphasize the uniqueness of sucrose, is their earlier and basic discovery that the enzyme from *Pseudomonas saccharophila*, which is capable of



Haas and Associates Photo

H. A. BARKER, H. Z. HASSID, AND M. DOUDOROFF

IN THE LABORATORY AT THE UNIVERSITY OF CALIFORNIA WHERE THEY WORKED OUT TECHNIQUES FOR THE FIRST RECOGNIZED ENZYMATIC SYNTHESIS OF SUCROSE. FOR THIS WORK THEY RECEIVED THE FIRST ANNUAL $5,000 SUGAR RESEARCH AWARD GRANTED BY THE NATIONAL SCIENCE FUND.

splitting sugar, does not form a simple mixture of dextrose and levulose. This enzyme requires phosphate in order to function, and it brings about a direct splitting of sucrose into levulose and a dextrose phosphate. The fact that something other than a simple dextrose-levulose mixture is formed again emphasizes the individuality of sucrose and that it may behave differently from simple invert sugar. This further indicates the need for much specific study of sucrose in the field of physiology.

Other phenomena that have recently been observed are in accord with the evidence that sucrose and invert sugar are by no means equivalent physiologically. We have mentioned the finding of Rabinowitch, who has shown that sucrose taken by mouth seems to raise the dextrose level of the blood faster than either dextrose taken by mouth or mixtures of dextrose and levulose. On the older theory that sucrose and invert sugar are physiologically equivalent, this fact cannot be explained. However, it fits in perfectly with the foregoing factual discussion, which shows why sucrose and invert sugar might be expected to behave differently.

Furthermore, should it prove to be true that sucrose is cleaved, in the body, directly to levulose and dextrose *phosphate*, as Hassid, Doudoroff, and Barker have found, instead of to free dextrose, then a mechanism for the difference observed by Rabinowitch would be at hand. It is known that all sugars must combine with phosphoric acid in the process of absorption through the intestinal wall. Hence, a cleavage of sugar to dextrose phosphate might expedite the process of getting sugar to the blood stream and give the disaccharide an actual advantage over dextrose taken as such.

It has also been observed by Robbins and by Went that excised tomato roots will grow well in cultures containing essential nutrients and sugar. They grow better in sucrose solutions than in solutions containing equivalent amounts of dextrose, levulose, or *mixtures of these two*.

The over-all effect of these studies is to create new consideration for the unique characteristics and specific properties of sucrose as a distinct and individual substance, which is not to be regarded as a mere mixture but as a compound requiring more extensive and intensive study in the fields of plant and animal physiology.

Dr. Carl F. Cori, Professor of Biochemistry at Washington University, St. Louis, Mo., and Dr. Gerti Cori were awarded the Second Sugar Research Award for their achievements in the study of carbohydrate metabolism in the animal body. This distinguished series of researches, extending over a period of twenty years, is so well known that it will be given no further exposition here.

Scientific Reports. The scientific literature abounds with reference to the uses of sugar for various purposes, in medicine, in the arts, and in the food and other industries. Very little of this material has been systematically collected and organized in the past. To fill the need for such organized and classified information concerning the numerous and varied uses of sucrose, the Foundation is undertaking to issue a series of Scientific Reports prepared by specialists in various fields.

Eight Reports in this series have been published:

1. *Sugar and Sugar By-Products in the Plastics Industry*, by Louis Long, formerly Research Associate in Chemistry, The Massachusetts Institute of Technology.
2. *Intravenous Administration in Clinical Practice*, by C. Jelleff Carr, Associate Professor of Pharmacology, University of Maryland Medical School.
3. *The Utilization of Sugar Cane Bagasse, For Paper, Boards, Plastics, and Chemicals*, An Annotated Bibliography edited by Clarence J. West, The Institute of Paper Chemistry, Appleton, Wis.
4. *Invertase*, A monograph by Carl Neuberg, Research Professor of Chemistry, New York University, and Irene S. Roberts, Dayton, O.

5 *The Uses and Functions of Sugar in Pharmacy*, by Paul S. Pittenger, Vice President in Charge of Quality Control, Sharp & Dohme, Inc., Philadelphia, Pa.
6. *Bacterial Polysaccharides*, by Taylor H. Evans, Research Chemist, Dominion Rubber Co., Ltd., and Harold Hibbert, late Professor of Industrial and Cellulose Chemistry, McGill University.
7. *Chemical Compounds Formed from Sugars by Molds*, by Bernard S. Gould, Associate Professor of Biochemistry, The Massachusetts Institute of Technology.
8. *Levulinic Acid as a Source of Heterocyclic Compounds*, by Avery A. Morton, Professor of Organic Chemistry, The Massachusetts Institute of Technology.

Two Technological Reports have also been issued:

1. *Patents on the Reactions of Sugars*, A digest by Alvin Guttag, Examiner, U. S. Patent Office.
2. *The Color Problem in Sucrose Manufacture*, by F. W. Zerban, Chemist in Charge, The New York Sugar Trade Laboratory, Inc.

These Reports, as well as the many papers already published by project directors in scientific journals, and the participation of project directors in numerous scientific meetings and symposia, have attracted the interest of individuals and groups in scientific circles here and abroad and resulted in the establishment of effective liaison between the Foundation and workers in related fields.

Even with the present world-wide shortage of sugar and the war-swollen output of certain other chemicals, the amount of sugar produced is still ten times greater than the next largest pure organic chemical. When a normal supply situation obtains and the basic facts about sugar are better understood, this cheap substance will become increasingly useful as a raw material.

Science is more and more turning its attention to utilization of the carbohydrates. It is our hope that the Foundation's fundamental studies will help to lay the necessary groundwork and make tangible contributions for the development of this promising field.

ADVANCE REGISTRATION

114TH MEETING OF THE A.A.A.S., CHICAGO, DECEMBER 26–31, 1947

Those planning to attend the Chicago Meeting of the Association, December 26–31, may register now by sending the correct registration fee ($2 00 for members and college students, $3 00 for nonmembers) to the Washington office of the Association, 1515 Massachusetts Ave, N. W. The *General Program* will be mailed on December 1 to all who register before that date, in time to study its contents and decide at leisure which of the many hundreds of sessions and special functions they may most profitably attend Moreover, they will be saved the time of registering during the meeting, and their names will be included in the special directory of registrants that will be available for inspection in all the headquarters hotels.

The *General Program* will list the papers of the sections and societies meeting with the Association, including the time and place of each session. It will also contain announcements regarding general sessions, the International Science Exhibition, eating facilities, transportation, mail and messenger service, and a directory of speakers and presiding officers. Readers will find the Summary of Sessions most useful.

Registration fees have been received since August 15, and they will be accepted for mail distribution of the *General Program* until December 10. Payments received after that date will be held and placed on file on December 26 at the main registration center located adjacent to the Exhibition in the Stevens Hotel. Upon identification, registrants will be given a copy of the *General Program*, and their registration cards will be placed in the Visible Directory. To avoid delay in receipt of your copy of the program during the Christmas mailing rush, please send your registration fee in time for it to reach the Washington office before December 1.

THE MYSTERY OF THE MIMA MOUNDS

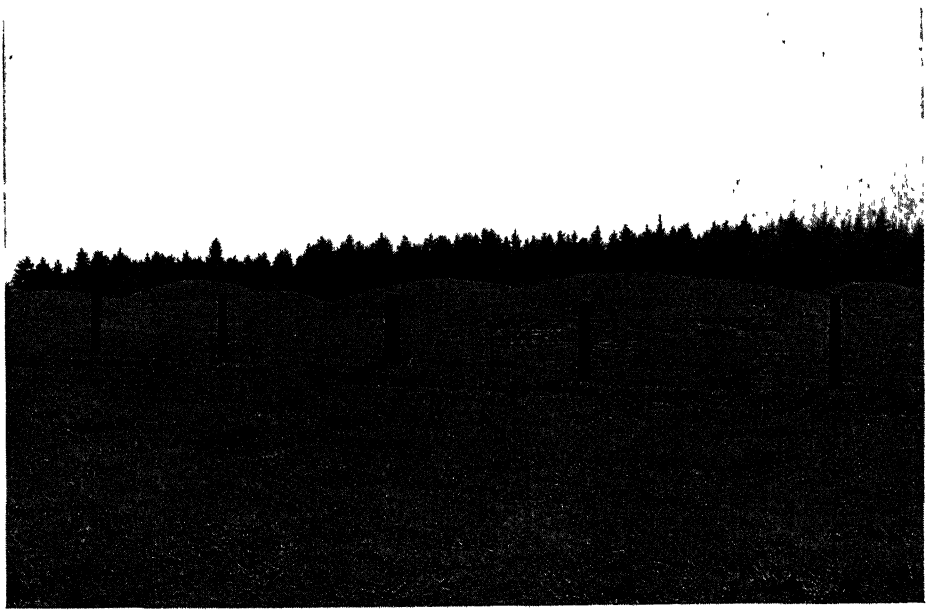
By VICTOR B. SCHEFFER

At present in Alaska in charge of research on the fur seal herd, Dr. Scheffer (Ph.D., University of Washington, 1936) is a biologist in the U. S. Fish and Wildlife Service, with headquarters in Seattle. He has specialized in studies of marine mammals; as a hobby he has delved into the giant earth mounds discussed below.

ON THE prairies of western Washington near the southern tip of Puget Sound are scattered thousands of large earth mounds whose origin has puzzled observers for more than a century. On Mima Prairie some of the mounds are higher than a man's head and have a content of 50 cubic yards. The mounds are smooth and round, like great spheres nearly buried in the earth. In many cases, the hollows between the mounds are filled with cobblestones up to the size of a football. In the spring of the year, when the mounds are covered with white-and-yellow daisies and green bracken ferns, they stand out clearly from their duller surroundings.

Wherever a mound has been sliced open by a roadway, a peculiar cross section is revealed. The typical mound is made up of soft black prairie silt mixed with pebbles up to the size of a walnut. The mound rests in a slight depression, or bed, in coarse, stratified glacial gravel, which continues downward for an unexplored distance. Thus, the typical mound is a biconvex lens, with the greater curvature exposed to the sky and the lesser curvature pressed against the gravel. At the base of the mound, armlike structures of black silt extend into the gravel. These have been called "mound roots" by certain investigators.

The origin of the mounds has long been



PROFILES OF MIMA MOUNDS SIX TO SEVEN FEET HIGH

IN THE FOREGROUND THE MOUNDS HAVE BEEN REMOVED BY FARM MACHINERY.

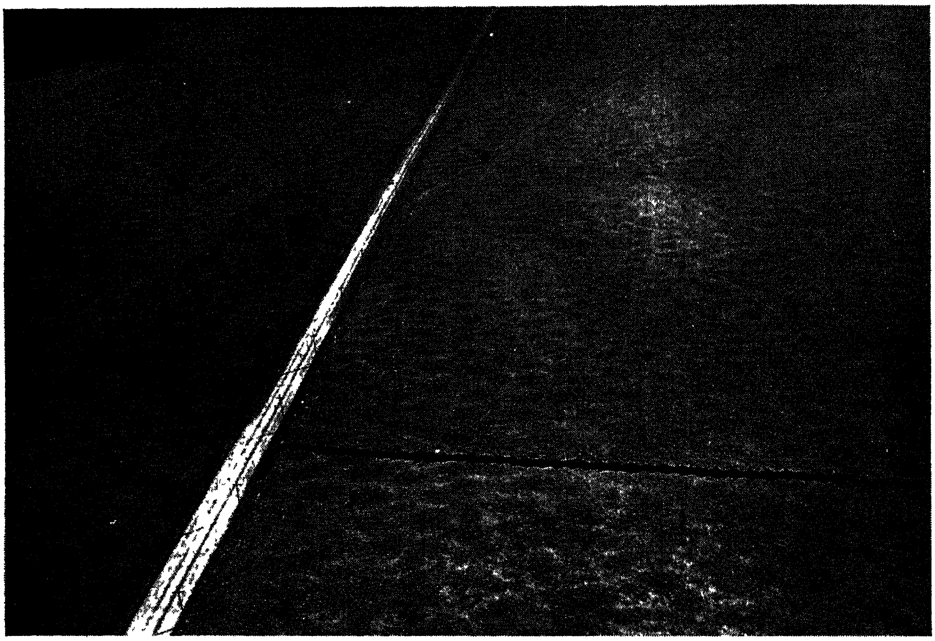


Photo by Army Air Corps

AN AIR VIEW OF MIMA MOUNDS

MOUNDS ON A GLACIAL OUTWASH PRAIRIE NEAR TENINO, WASH., AS SEEN FROM A LOW ALTITUDE

disputed. A few years ago, a student at the University of Washington suggested a novel theory to account for the mounds and invited me to join him in a search for supporting evidence. How we approached the problem and attempted to fit our findings into a convincing pattern has been described in a preliminary paper.[1]

As we delved into the mystery of the Mima Mounds, it dawned on us that these formations are kindred to similar, though less spectacular, mounds strewn by the millions over the Western states from the Mexican border to northern Washington. Thus, the theory accounting for the mounds of Puget Sound—which we now accept—embraces also the countless mounds of similar shape and structure in the Western states. Because of certain peculiar features, Mima Prairie has served as a Rosetta stone in explaining the origin of other mound prairies.

MORE than a century ago mound prairies drew the attention of travelers in the new West. In July 1842, Commander Charles Wilkes made a special trip to "Bute Prairie," south of Olympia, Wash., and dug into three of the mounds in an attempt to unlock their secret.[2] He finally concluded that "they bear the marks of savage labour, and are such an undertaking as would have required the united efforts of a whole tribe." As indeed they would!

On the famous railroad survey of 1853–56, naturalists Gibbs and Cooper examined some of the mounds, and Gibbs suggested that "they might have been produced by the immense growth of the 'giant root,' (*Megarhiza* (*Echinocystis*) *Oregana*), forming a nucleus around which the soil has been gradually washed away." Cooper—a more conservative scientist—believed that the mounds were perhaps the result of eddy and whirlpool action at a time when the prairies were submerged beneath Puget Sound.[3] When Gibbs returned to the East he described the mounds to Louis Agassiz, who

"unhesitatingly" pronounced them the nests of a species of sucker. Professor Agassiz may be forgiven this opinion in view of the fact that he had not seen the mounds, some of which rise to a height of seven feet.

Joseph LeConte, geologist of the University of California, first saw the Puget Sound prairies in 1871. He was the first to point out the similarities among the mounds in California, Oregon, and Washington and he tried to show that their origin was due to "surface erosion under peculiar conditions."[4] As he reconstructed their geological history, the prairies were left by a retreating body of water with a blanket of fine topsoil and a coarse subsoil; erosion started to remove the finer topsoil everywhere but in certain spots; weeds, shrubs, and ferns immediately seized upon these spots, or islands, and anchored the soil; then when the climate grew drier, vegetation was able to survive only on the higher (and richer) islands while erosion continued to gnaw at their bases.

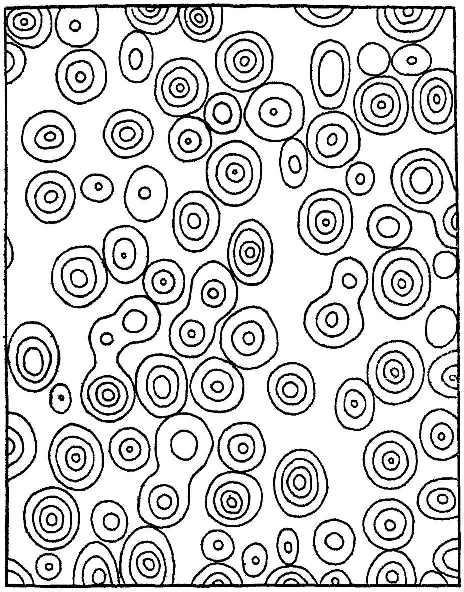
Interest in the American earth mounds was aroused in faraway England. Geologist Alfred R. Wallace discussed a letter from his brother in California describing the "hog-wallow" region of the San Joaquin Valley.[5]

> The surface thus designated [he wrote] may be represented on a small scale by covering the bottom of a large flat dish with eggs distributed so that their longer axes shall lie at various angles with one another, and then filling the dish with fine sand to a little more than half the height of the eggs.

The California brother attributed the mounds to "innumerable rills that issued from the retiring sheet of ice" of a glacier long since disappeared. (It is now well established that the San Joaquin Valley was at no time covered by ice.

Soon afterward, G. W. Barnes discussed the small hillocks that lie on the old sea terraces back of San Diego.[6] He concluded that the San Diego mounds were produced—and

MIMA PRAIRIE, THURSTON COUNTY, WASH.
THIS IS THE TYPE LOCALITY OF THE MIMA MOUNDS.


Courtesy of J Harlan Bretz

MOUND TOPOGRAPHY

CHARACTERISTIC ARRANGEMENT OF MOUNDS ON MIMA PRAIRIE; CONTOUR INTERVAL, TWO FEET.

are still being produced—by a peculiar combination of wind and water erosion in the presence of vegetation, as follows: prevailing winds deposit dust and leaves at the base of a shrubby desert plant; rain-water erosion cuts faster at the base of the mound than at the top; the shrub eventually dies; and, "deprived of its protection, the summit is reduced and the base widened as it is lowered, till finally a remnant of the deposit has become so assimilated and compact as to constitute a more permanent summit." Accompanied by Dr. K. O. Emery, I examined the San Diego mounds in 1943 and found them very like the mounds of Puget Sound.

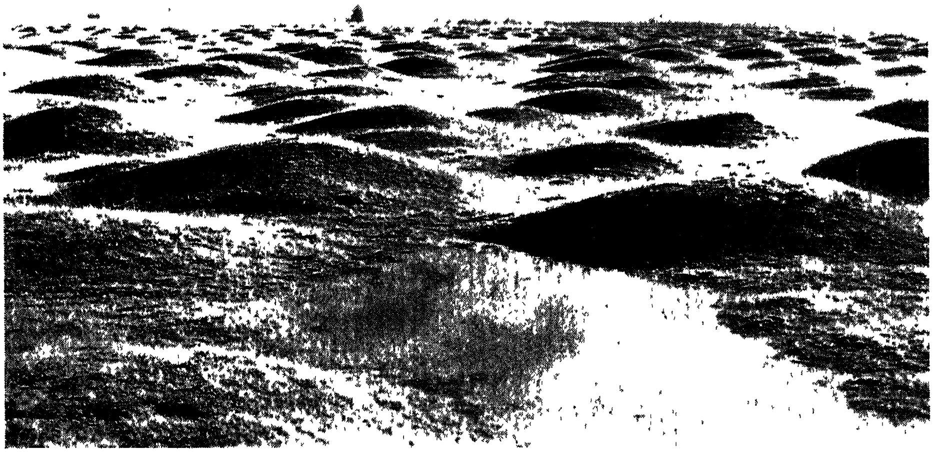
In a résumé in 1905, J. C. Branner disposed of a number of theories to account for the Western mounds and concluded: "The ant-hill theory seems to me the most plausible, but with our present knowledge it is far from satisfactory."[7] He also dwelt on the concept that the mounds are the result of differential solution and concretion on a large scale.

Marius Campbell, of the Geological Survey, followed shortly with a paper summarizing the various hypotheses for the mounds that lie on the plains from Arkansas to the Pacific coast.[8] He showed that naturalists had laid the origin of the mounds to the agency of humans, burrowing mammals (ground squirrels, gophers, and prairie dogs), ants, fishes, water erosion, chemical solution, wind action, physical and chemical segregation, glacial action, uprooted trees, and spring and gas vents. Campbell suspected the importance of burrowing mammals and ants, especially the latter, although he confessed his inability to understand their methods of operation

In 1913, J. Harlan Bretz, of the University of Washington, published an article on glaciation of the Puget Sound region and therein described his careful studies of Mima Prairie.[9] He concluded that the mounds were probably the result of water and ice action. In retrospect, it seems logical that Bretz should have associated the mounds with glacial activity since the region under scrutiny, where the mounds are better developed than anywhere else in the United States, marks also the farthest point reached by the Vashon Glacier, last of the Western ice sheets.

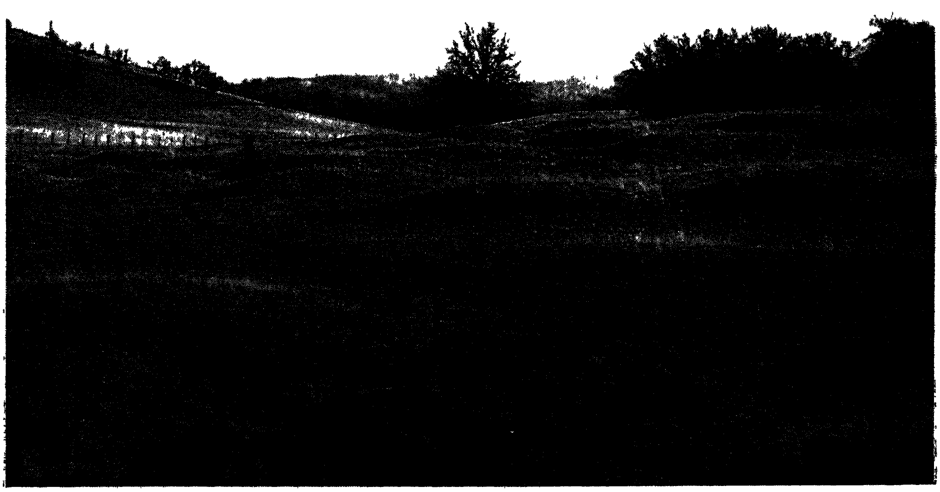
Ellis and Lee, in 1919, laid the origin of the San Diego mounds to "the action of wind as it sweeps through the sparse desert vegetation and blows away the loose soil except where it is held by plant roots."[10] These investigators, like certain others before them, apparently did not realize that wind-built mounds are invariably *oriented* with the direction of the prevailing wind, whereas the mounds in question are either round or, if elongated, are aligned in no common direction.

The theory has been suggested, with variations, that the great power of freezing water has been instrumental in creating the mounds. The proponents of this theory may have studied the mound prairies of the



Courtesy of C C Nikiforoff

MIMA-TYPE MOUNDS IN THE "HOG-WALLOW" COUNTRY NEAR FRESNO, CALIF.



MIMA-TYPE MOUNDS ON LITTLE DRY CREEK, FRESNO COUNTY, CALIF.

BOULDERS DUG UP BY GOPHERS

THE LARGEST BOULDER HERE WEIGHS ABOUT TWENTY-FIVE POUNDS.

North, but surely not those of the warm coastal plains of southern California.[11]

In 1941, soil-scientist C. C. Nikiforoff published a long report on his studies of mounds in the Central Valley of California, principally in Tulare County.[12] The mounds here are so similar in shape, size, and arrangement to those of Puget Sound that certain photographs from the two areas appear to have been taken from the same station. In two respects, however, the regions are different: in Tulare County the mounds are underlain by a stiff clay hardpan and in the rainy season may be surrounded by water a foot or two deep, whereas in Puget Sound the mounds are underlain by coarse gravel and rarely, if ever, stand out as islands. Nikiforoff concluded that the "hog-wallow microrelief" was perhaps the result of ground-water pressure from the Sierra Nevada pushing up through countless "windows", now represented by mounds, in the hardpan of the valley.

A "MOUND ROOT"

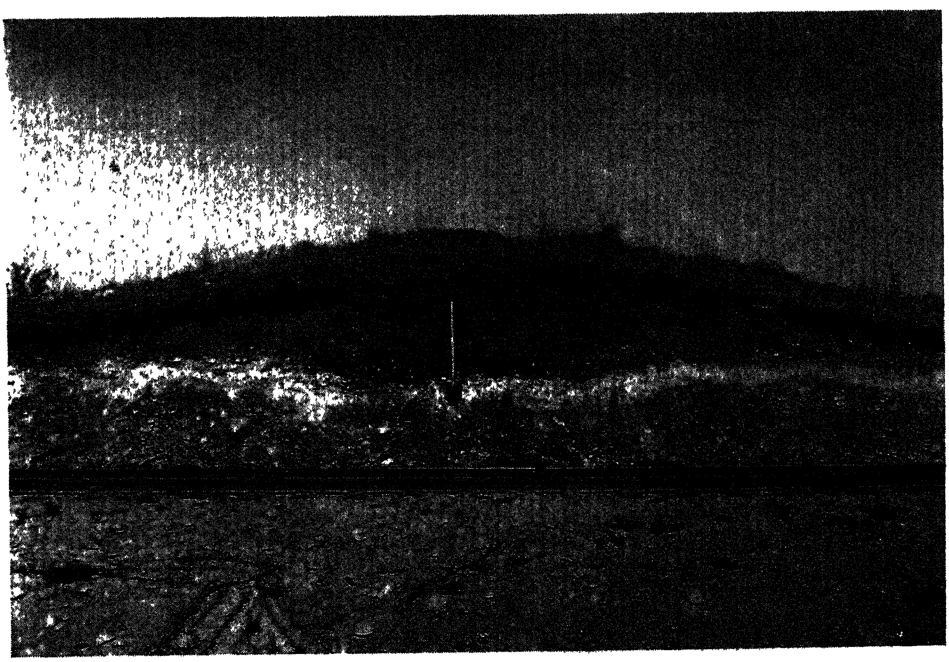
THE CAVITY IS FILLED WITH BLACK SILT.

The mounds in the Central Valley are so numerous, or were when the pioneer farmers arrived on the scene, that a special implement, the "Fresno Scraper," has been devised for the purpose of leveling them off and making the ground fit for cultivation. The machine is still widely used.

THE foregoing statements high-light the history of research on Mima-type mounds. In 1941, Walter W. Dalquest was engaged in a survey of the mammals of the state of Washington. As he extended his field observations to the prairies near Mima, he was at the same time enrolled in a course in glacial geology at the University of Washington. Here he learned that the origin of the prairie mounds was a mystery. About then the idea struck him that the mounds are the handiwork of pocket gophers over untold periods of time. When he broached the idea to old-timers born and raised on the prairies, they commonly put tongue in cheek and cautiously remarked, "W-e-e-l, they must have been pretty big gophers." This is a not illogical conclusion in view of the fact that the Mima Mounds are among the most spectacular—if not the largest—structures created by any mammal.

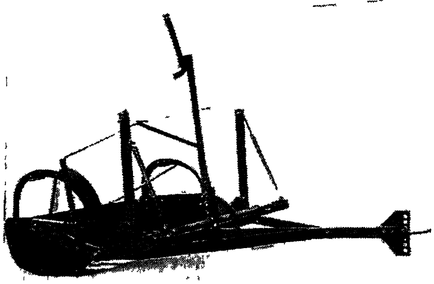
GOPHER POCKETS IN CHEEKS

The gopher of the Western states, *Thomomys*, is a ratlike, brownish rodent that burrows in the soil of prairies and mountain meadows and along stream channels in the



A MIMA MOUND SLICED OPEN BY A RAILROAD GRADE

SHOWING THE TYPICAL LENS-SHAPED BODY OF BLACK SILT RESTING ON A BED OF LIGHT-COLORED GRAVEL



Courtesy of Solano Iron Works

THE FRESNO SCRAPER

FOR REMOVING MIMA-TYPE MOUNDS FROM THE CENTRAL VALLEY OF CALIFORNIA.

desert. It seldom ventures aboveground (as does the ground squirrel) and never enters the shade of the forest (as does the mole). It feeds on fleshy roots and often pulls an entire plant, root-first, into its subterranean chamber. The "pocket" part of the gopher's name refers to a deep, fur-lined pouch in each cheek. The pouch is about the size of an ordinary thimble and is used for carrying food, nesting material, and dirt. With this pouch to serve as a hod, with a pair of powerful forepaws for digging, and with the ability to run backward as well as forward in its burrow, the gopher is well equipped to excavate its labyrinthine tunnels.

Our theory of the origin of the Mima Mounds by gopher activity may be summed up as follows: A few tens of thousands of years ago, the Puget Sound prairie was laid down by rivers draining from the Vashon Ice Sheet. At first, the rivers were powerful and were able to carry the large boulders now found in the substratum of the prairie. Later, the rivers were quieter and were able to carry only the fine silt that, richened and darkened by the addition of grass-root humus, now composes the topsoil.

As soon as vegetation captured the raw new soil, we suppose that pocket gophers came in from the unglaciated country to the southward, advancing perhaps a few hundred feet in a gopher generation. By the

Courtesy of T H Scheffer

A GOPHER TUNNEL NEAR CORVALLIS, ORE.

THE EXCAVATION REVEALED THE NEST WITH FIVE NEWBORN YOUNG.

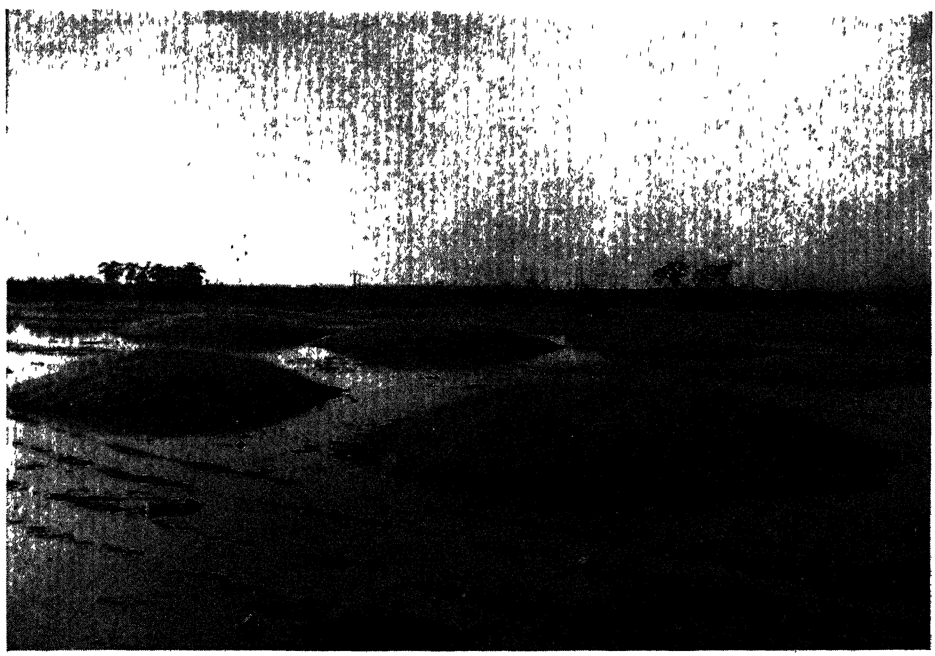
time they reached the southern end of Puget Sound they encountered a barrier, the evergreen forest that had been racing against them to occupy the new land. There they were stopped, and, to the present day, no gophers are found on the lowlands of the Pacific coast north of southern Puget Sound. To be specific, the northern limit of the gopher range is Point Defiance Park, in Tacoma.

We can picture then, thousands of years ago, gophers rooting through the thin silt of the Puget Sound outwash in search of plant roots. At certain places they dug deeply into the gravelly subsoil in order to make nest chambers well protected from prowling bear, wolf, or wildcat. Areal spacing of the nest chambers corresponded to the size of the "territory" of each animal. The center of an old territory now marks, we believe, the center of a modern mound.

In excavating for its nest chamber, the gopher was instinctively led to dig deep into the bedded gravel, regardless of the effort involved. When the animal ran into a large boulder it undermined the obstruction and allowed it to settle. Thus, we now find, at the base of most mounds, a concentration of

A POCKET GOPHER

A TAME ANIMAL (*Thomomys talpoides yelmensis*) FROM A PUGET SOUND PRAIRIE.



MIMA-TYPE MOUNDS ALONG A ROAD NEAR SAN DIEGO, CALIF.

DRAINAGE OF RAIN WATER IS SLOW BECAUSE OF A DENSE, UNDERLYING HARDPAN.

THE TAILINGS FROM A GOPHER MINE

A ROPELIKE MASS OF EARTH ON THE SURFACE OF A MOUNTAIN MEADOW IN EARLY SUMMER. A GOPHER DISPOSED OF WASTE CLODS BY PUSHING THEM INTO A SNOW TUNNEL. AFTER THE SNOW MELTED, THIS EARTHEN CAST WAS EXPOSED.

coarser materials. On the other hand, in foraging daily for food over its home range, the gopher was driven by less powerful instincts. When it encountered a bothersome rock in its path, it simply passed around it, shoving dirt along as it went. Thus, we find plainly exposed in the intermound hollows large boulders that were doubtless at one time buried in the topsoil.

GOPHER FOOD

FOOD STORE OF A GOPHER FROM TACOMA, WASH. THE STORE WAS ABOUT FOUR INCHES BELOW THE SURFACE OF THE GROUND. IT CONTAINED TWO QUARTS OF CUT RHIZOMES OF QUACK GRASS.

Where the mound and its bed are in contact, there are found "mound roots," long a puzzle to geologists, which are simply abandoned gopher tunnels now filled with black silt contrasting in color with the yellow gravel around it. (They call to mind the peculiar devil's corkscrews, or *Daemonelices*, of the Nebraska sediments.[13] Once described as fossil plants or animals, the corkscrews are now generally believed to be the casts of burrows of extinct rodents.) We can imagine that, in cases where a gopher mound was abandoned by its owner for some reason or other, the nesting chamber collapsed and caused a depression at the crest of the mound, a characteristic feature of many of the mounds on Mima Prairie.

In fancy, it is easy to picture the start of a Mima Mound. It is less easy to account

for its growth. For reasons that may never be known, the gophers carried more dirt toward the nest than away from it. Perhaps some biologist will suggest an experiment whereby the growth of a Mima-type mound can be studied from start to finish. At present, we do not know whether the mounds on the Puget Sound and other prairies are still growing, whether they are in equilibrium with the forces tending to reduce them, or whether they are shrinking.

In reviewing our evidence in support of the gopher-origin theory, we realize that most of it is indirect. We cannot say that we have seen a gopher, or a family of gophers, build a giant mound. Yet, as each new fact with regard to the mounds is uncovered, it seems to strengthen the gopher theory. And, what is perhaps more important, no counter-theory based on the action of nonliving forces (such as wind and water) approaches a satisfactory explanation of the peculiar structure and arrangement of the mounds. The following facts have led us to our conclusions:

1. Mima-type mounds are distributed along the Pacific Coast exclusively in the range of the pocket gopher. On the north, both the mounds and the gophers terminate abruptly in the vicinity of Puget Sound.

2. Burrowing animals with habits similar to those of the gopher, namely, the ground squirrel (*Citellus*) and the mole (*Scapanus*), are known to occur on many of the mound prairies. We may deduce, however, that these animals are not pertinent to the formation of mounds since there are no ground squirrels in western Washington and no moles on most of the mound prairies of California.

3. Mima-type mounds are found only where there is a thin layer of workable soil on top of a dense substratum. It is significant that the substratum is of no particular geological formation. Thus near San Diego and Fresno, the substratum is a hardpan of cemented soil; a few miles southeast of Mount Hood, in Oregon, the substratum is basaltic rock; and in Puget Sound it is bedded gravel.

4. Where gophers are working in deep sandy soil unlimited by a basement they never form Mima-type mounds. In other words, their up-and-down movements are not restricted or localized. In deep soil near Olympia, Wash., only fifteen miles from the mound display at Mima, gophers have been working for untold years, and the surface of the ground is still so level that it is used as an airfield.

5. The usual agent in the formation of hillocks and mounds is geological deposition of one kind or another. This agent can hardly be responsible for mounds of the Mima type. Deposition, whether by ice, wind, or water, depends on a moving vehicle, and movement always results in a deposit which is aligned in one general direction. Mima-type mounds, as may be seen from aerial photographs, are unoriented. Also, deposition does not produce round mounds on a sloping terrain, as are occasionally seen on the gopher prairies.

6. For similar reasons, the agency of erosion may be dismissed. Erosion is generally the result of a moving vehicle. We may point out, further, that on the Puget Sound prairies, the mounds are draped the year around with a mossy turf that protects them from wind and rain-water erosion. And, in countless cases, the hollows between the mounds are completely closed depressions from which there is no rapid outflow of water—simply drainage through the porous gravel bed.

7. Only by a liberal use of the imagination can we conceive of a set of geological forces capable of producing the elaborate structure of the mounds, namely: the fluffy, unstratified soil of the mound adjoining a distinctly bedded substratum; the presence of "gopher-size" rocks in the mound as compared with the heavy cobbles beneath and beside the mound; the curious dip in the substrate beneath the mound; the mound roots; and the sunken depression usually found on the summit.

The reader may be disturbed to learn that *there are no gophers on Mima Prairie*, where climax examples of the mounds appear. This fact is of little importance, however, since there is clear evidence that gophers once lived there. Through some unknown agency—fire, flood, or pestilence—they were wiped out. Once gone from the prairie, they would not return, for the prairie is now isolated from surrounding gopher range by a river and a forest. Since the Mima Prairie Mounds are identical in structure with others only a mile away where gophers *are* found at the present time, we feel confident in stating that both series of mounds are of common origin. And, as we have pointed out, Mima Prairie is only one among scores of plains along the coast where Mima-type mounds occur.

Finally, we should like to pose three questions, the answers to which some enterprising naturalist may be led to seek:

First, what are the dynamics of mound formation? Were the present mounds built in a matter of years? Centuries? Do conditions of the environment favor their growth at the present time?

Second, does ground water at certain times of the year and in certain localities act in the same way that a soil hardpan does, to force the gophers into mound-building activity?

Third, how widespread in North America are gopher mounds of the Mima type? Shortly before his death in 1942, government naturalist Vernon Bailey told us that he had puzzled over Mima Prairie for years and wondered whether some giant gopher might have lived there long ago. He also said that in his extensive travels he had seen similar formations in southwestern South Dakota, southwestern Louisiana, eastern Texas, and many other parts of the West. Only in California, Oregon, and Washington have we had an opportunity to study them.

REFERENCES

1. Dalquest, W. W., and Scheffer, V. B. *J. Geol.*, 1942, **50**, 68.
2. Wilkes, C. *Narrative of the United States Exploring Expedition during the Years 1838, 1839, 1840, 1842*, 1850, **4**, 415.
3. Cooper, J. G. In *Reports of Explorations and Surveys to Ascertain the Most Practicable and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean, 1853–1856*, 1860, **12**, (2), pt 2, 19.
4. LeConte, J. *Proc. Calif. Acad. Sci.*, 1873, **5**, 214; *Amer. J. Sci. and Arts*, 1874, **7**, 167.
5. Wallace, A. R. *Nature*, 1877, **15**, 274.
6. Barnes, G. W. *Amer. Nat.*, 1879, **13**, 565.
7. Branner, J. C. *Science*, 1905, **21**, 514.
8. Campbell, M. R. *J. Geol.*, 1906, **14**, 708.
9. Bretz, J. H. *Wash. (State) Geol. Surv. Bull.*, 1913, **8**.
10. Ellis, A. J., and Lee, C. H. *U. S. Water Survey Pap.*, 1919, **446**.
11. Eakin, H. M. *Science*, 1932, **75**, 536.
12. Nikiforoff, C. C. *U. S. Dept. Agr. Tech. Bull.*, 1941, **745**.
13. Lugn, A. L. *J. Geol.*, 1941, **49**, 673.

INCREASE IN DUES FOR 1948

By action of the Executive Committee annual dues to the A.A.A.S. will be increased from $5.00 to $6.50, effective October 1, 1947, and applying to the journals to be delivered during 1948. If a member wishes to receive both *Science* and The Scientific Monthly, the charge will be $10.00. Non-member subscriptions to *Science* and The Scientific Monthly will be $7.50 per year each, plus, in the case of *Science*, foreign postage (outside the Pan-American Union, $1.00; Canada, 50 cents.) Rates for The Scientific Monthly for periods of less than one year will be computed at 75 cents per month.

TOWARD A SCIENCE OF HOUSING

By C. THEODORE LARSON

Mr. Larson (M. Arch., Harvard Graduate School of Design, 1929) has been architect and project planner for the U. S. Housing Authority, technical editor of Architectural Forum, *architect with the N H.A., and technical consultant for the Kilgore Subcommittee on War Mobilization, Military Affairs Committee (1944–45). Since March 1947 he has been with General Homes, Inc., Columbus, Ohio.*

THE age of synthetics has given us unlimited freedom in design—instead of having to shape our dwellings to meet the limitations of materials as made by nature, we can now tailor them to conform with whatever patterns of family and community living we find most desirable. Walls need no longer be inert masses of masonry with no function other than to hold up the roof and provide shelter against a harsh external environment. They can be made to do extraordinary things—radiate warmth or coolness, glow with soft light, move about, perform household chores, ward off or destroy harmful organisms, otherwise serve man's bidding. The design objective becomes *control* of environment—the development of new forms that will promote man's health and comfort, increase his productive capacities, and enable him to develop physically and culturally beyond any standards of perfection he has ever dared set for himself in the past.

Such is the promise. But, between this bright new architecture and what actually exists, there is an enormous gap. The closing of this gap calls for further scientific and technological progress.

The problem. Our housing supply is notoriously deficient. Since 1900 the output of new houses has not been large enough to keep up with the increase in families. As a result, the nation's housing has deteriorated progressively—we have not been able to build new houses as fast as existing units were wearing out. The 34,854,532 dwellings in the United States, according to the housing census of 1940, had a median age of over twenty-five years; surprisingly large percentages lacked running water, private baths, flush toilets, electricity, and refrigeration; 14 out of every 100 needed major repairs before they could be called safe for human occupancy. Slums and congestion and blight have been steadily spreading like an insidious disease. Now, as an aftermath of war, the accumulated shortage of dwellings is revealed in its full enormity. So great is the need that even if the building industry attains and holds a production volume of 1,250,000 units a year for 10 years, we shall still be nearly 4,000,000 units short of the total the National Housing Agency estimates as necessary to take care of anticipated population increases and to replace existing dwellings which fail to meet even the lowest standards of health and decency.

This housing deficit is directly attributable to the fact that the housebuilding industry has fallen behind technologically. Methods and materials used centuries ago are still in use. Houses built in such fashion are too costly for the average citizen's pocketbook; year by year they have been getting more rather than less expensive. Output consequently has been low. In 1925, the highest peak year on record, only 937,000 new dwellings were built, and in 1933, a depression year, production sank to a low of 93,000 units. Despite an unprecedented number of construction starts last year, completions have lagged and home building again is at a virtual standstill. In short, the industry has been steadily pricing

itself out of the market. Only the wealthy are able to afford new houses; other families must double up and triple up in obsolete hand-me-downs.

High labor rates, high material prices, and high charges for financing are usually blamed for the high costs of housing, but, even if these were lowered (as they have been in instances), houses built along traditional lines would still be excessively expensive because of the industry's inherent inefficiencies. Too much time is required to produce such houses—and time is costly.

The conventional house is an assembly of many small bits and pieces—approximately 30,000 different kinds—all of which are individually fabricated in various plants and must be delivered to a particular site and laboriously fitted together into a complete structure. An ordinary wall is built up in a dozen or more layers in a complicated composite of paint, siding, kraft paper, sheathing, nails, screws, studding, insulation, lath, plaster, paste, and wallpaper or their equivalents. Usually, to produce such a house, some 4,500 to 5,000 man-hours of labor are required. Roughly two-thirds of this time is spent in processing and shipping the elaborate array of materials to a building site, the other third in putting them together as a structure.

As a general rule, site work can proceed only when the weather is favorable. Long delays occur if there are wet spells or freezing. Construction workers consequently have had to be paid high hourly wages in order to hold them in the building trades. Even so, because so much time is lost on the job, their total annual wages have generally been lower than those in the mass-production industries. They have seldom been able to afford the products they themselves have helped produce. Like other homeseekers with limited incomes, they have had to be content with secondhand dwellings.

Here clearly is an important area for technical research and development. Home building must be freed from its traditional dependence on weather. At the same time techniques must be developed that will step up the productivity of the individual construction worker so that the unit costs of housing can be lowered without cutting established wage rates and the purchasing power of potential customers. With year-round production and a guarantee of a substantially higher annual income, there should be little reluctance on labor's part to accept more efficient modes of construction.

New production approaches. The problem of a backward building industry has been recognized for a long time. During the 1930's numerous house producers saw the importance of not being tied to the weather and began to do something. By transferring as many site operations as possible to a central plant (in some cases simply a large tent on the building site), these pioneers in house prefabrication made it possible for their mechanics to work indoors continuously, rain or shine. In the process they also cut the 1,500 to 1,800 man-hours usually required for outdoor site-erection work down to 300 man-hours, or even less. Such time reductions, however, were obtained chiefly by increasing the amount of work done in the factory. The average net over-all saving in man-hours has been only about 8 percent, according to a comparative study of prefabricated and conventional war-housing projects undertaken by the Bureau of Labor Statistics at the request of the National Housing Agency. As the war-housing experience also shows, greater economies can be obtained through large-scale operations directly on the site: when several hundred dwellings are built at a time, the flow of work can be so organized that construction time per unit is cut almost in half, with a corresponding saving in site labor costs.

Because the house prefabricators have not been able to cut costs substantially, their output has been relatively low. Last year,

according to the Office of the Housing Expediter, some 37,200 units were produced by 198 companies—an average of 180 units for each producer. This can hardly be called mass production.

Obviously, it is not enough merely to move indoors the usual sawing and hammering together of small bits and pieces. More advanced techniques of fabrication are needed to take advantage of the shift to the factory and to get the full economies implied by industrialization. The production of a house must be viewed as a single integrated process that extends all the way back to the original sources of supply—the forest, the mine, the quarry, and the farm. If this is done, then large abbreviations of time can be made at every step where there is any handling or processing of materials. All such time savings should be directly translatable into dollar savings for the housing consumer.

The necessity of this more fundamental approach to the problem of cost reduction has become increasingly evident as the nation's housing need has grown more acute. Thus, paradoxically, while the government's program of housing for veterans has been bogging down because of the inability of conventional builders to produce at reasonable prices, there has also been notable progress toward a higher level of industrial efficiency in home-building.

Numerous new producers are tooling up to enter the housing field. To a large extent these producers come from the aircraft industry and other war-expanded industries which have facilities that can be readily adapted to the manufacture of low-cost houses. Unlike the earlier house prefabricators whose units have differed little from the conventional house in design or construction, these newcomers are experimenting with new materials, new designs, and wholly new systems of house fabrication.

The Harmon Corporation, for example, has developed a steel panel house which it expects soon to produce at the rate of 1,000 units a month at its converted shipyard plant at Wilmington, Del. Another typical new producer is the Butler Manufacturing Company, Kansas City, Mo., which has utilized its experience in fabricating metal grain bins and store fronts to develop an attractive aluminum panel house. Reliance Homes, Inc., of Philadelphia, has been experimenting with a house which can be made in either steel or aluminum sections measuring up to 8 by 25 feet; these sections will be nested together on truck trailers, transported to the site, and rapidly put in place by cranes.

Porcelain enamel likewise is acquiring a new prominence in house building. The Lustron Corporation, a subsidiary of Chicago Vitreous Enamel Products Company, is planning to turn out 15,000 houses a year utilizing a system of ceramic-surfaced steel panels. Bathtubs and other fixtures are easily shaped out of the wall material and made an integral part of the structural shell. Andrew Higgins, the New Orleans shipbuilder, has been experimenting with a similar structural system. Large prefabricated wall panels, with doors and windows incorporated, are delivered to the site and butted end to end; then, after pipes and wiring have been run through the hollow insides, a "foamed" concrete mixture is pumped into the panels. This forms, in effect, a 2-inch monolithic concrete wall faced inside and out with steel sheets prefinished in any desired color. To mothers with small children the ceramic wall surfaces offer a special attraction; a damp cloth readily removes any smudges or hand prints.

These new producers look upon themselves as housing manufacturers. Already, even before most have completed their tooling and gotten into full stride, they have set up their own trade association. They shun the term "prefabrication." Instead, they talk about "industrialized houses" and the implications of using new structural materials.

Creation of materials. Logically, there should be a single material versatile enough in itself to do everything that the present multiple wall and roof materials are required to do. As stated by the National Housing Agency in an analysis of housing costs issued shortly before the war ended:

> If a building material could be developed which would permit the economical molding by mass-production methods of monolithic self-supporting wall panels, containing all the characteristics which are essential in the exterior and interior walls of a house, as well as self-supporting roof and floor panels, a very important step would have been taken toward solving the problem of excessive housing costs.

Such a single, multipurpose material, it was hinted, should be able to cut the cost of the house shell at least in half. The net effect would be to reduce the total capital cost of house and land by approximately 30 percent.

Significantly, much of the current experimentation in building materials points in this direction. An outstanding example is the aluminum-faced, plastic, honeycomb-paper core panel being developed by Lincoln Industries, of Marion, Va., in collaboration with the Forest Products Laboratory. This material is a direct outgrowth of the plastic fiberglas radomes (radar equipment enclosures) developed for use on Navy planes during the war. Paper sheets are run through alternating glue-strip rollers, stacked, and gang-sawed into slices 2 to 4 inches thick. Each slice is then pulled out, like an old-fashioned paper Christmas bell, to form a honeycomb core, which is impregnated with a plastic resin and sandwiched between thin sheets, or "skins," of aluminum. The resulting panel is lighter than cork, has surprising strength, and can be made in large, easily handled sizes. Units snap-lock together on the site to form finished walls and roofs. The whole process can be mechanized. Even in the laboratory stage, only two weeks are required from the time the paper and aluminum sheets are fed in at one end of the production line until a house is ready to move into. Three airplane companies—Douglas, Consolidated Vultee, and Goodyear—have been building experimental houses using the Lincoln material and a similar material produced by the U. S. Plywood Corporation. Their production plans, however, are still indefinite.

An engineering firm in Cleveland—the H. H. Ferguson Company—has been sponsoring experiments with a panel system which uses sheets of corrugated paper glued together and then impregnated with various plastic resins. The type of resin used determines the structural behavior; panels can be varied in toughness and strength, as well as being made fireproof, waterproof, and verminproof. For extra strength plies can be folded together to form reinforcing ribs of variable depth and spacing. At present the plastic-paper panels are used only in making cargo containers and movie sets, but it is expected that their use will be extended eventually to low-cost houses.

Cotton also offers long-range possibilities as a building material, although currently its cost is too high. During the war experimental samples were produced by the War Production Board's Office of Production Research and Development showing that it is technically possible to float cotton fibers into thin films of plastic and then to laminate these sheets into a hardboard that can be pressed into any desired structural shape. Such cotton-reinforced plastic material, if it can be produced cheaply, would be in demand for the manufacture of sinks and bathtubs as well as for structural panels, and the cotton-growing South would play an important role in the development of the industrialized house.

Wood likewise presents a fertile field for research. When a tree is cut up into ordinary lumber, at least 75 percent is lost in stumpage, lopped-off branches, discarded bark, shavings, and sawdust. This fact has stirred

numerous experimenters to create new type wallboards by mixing sawmill sweepings with cement, plastic resins, or other binders (even lime and skim milk have been tried). The most promising avenue of attack appears to be to reduce wood to its basic elements—cellulose and lignin—and then to use or recombine these elements in various ways with other basic materials.

In the case of concrete, there is considerable current experimentation with new lightweight aggregates—vermiculite, perlite, pumice, tufa, "bloating" clays, and even organic substances like straw, palmetto, and cottonwood fibers. Precast concrete panels made from such aggregates are said to have better insulation and greater resistance to moisture penetration than the older, denser types. In addition, they have the industrial advantage of weighing considerably less—an important consideration when it is remembered that the conventional house weighs 30 to 50 tons and requires excessive brute labor merely for its handling during construction.

The N.H.A. goal of a single, multipurpose building material may not be far distant. As these examples show, the paths of research cut across each other: the new synthetics are essentially alike in that they are all capable of being varied in form and substance to meet different conditions. What the ideal synthetic will be—whether it should be made from things that are grown or things that are mined or quarried—is mainly a question of research and economics. Possibly the answer lies in the field of low-pressure plastics. In any event, there is evidence of a great ferment of activity directed toward the creation of new-type building materials.

Evolution of standards. The legislation under which the government has been extending market guarantees and other financial assistance stipulates that every new type of house or material must be tested for sound quality. Since N.H.A. has no testing facilities of its own, it has had to rely on public and private testing laboratories for such work. Besides the National Bureau of Standards and the Forest Products Laboratory, the principal testing facilities include the U. S. Public Health Service, the Bureau of Reclamation, and the Bureau of Entomology and Plant Quarantine. Also active is the Engineering Research Station at Pennsylvania State College, which boasts a "climatometer" built originally with W.P.B. funds to test military equipment under varying climatic conditions.

As this network of testing laboratories has discovered, it is not always an easy task to measure the adequacy of structural innovations. Steel and aluminum houses present special problems of heat flow and moisture condensation. Some of the structural systems employ such novel engineering principles that values cannot be readily computed, nor do loading and racking tests developed for conventional construction always provide a sufficient index of actual strength. The durability of new materials is another big question mark. Various accelerated aging tests have been devised which put materials through severe temperature and humidity changes, but although any substance that survives such testing can be considered durable enough for housing use, there is as yet no precise correlation between the length of the test cycles and the actual life expectancy of the material.

A prerequisite to developing more advanced techniques of testing is knowing exactly what to test for. Unfortunately, the only standards we have are the specifications that have evolved out of many years of practical experience with conventional building materials. Once established, they are difficult to change. And, because house construction has been largely a local activity, each locality has its own accumulation of such standards—there are, it is estimated, some 2,000 different local building codes in

the United States. Each of these codes represents a separate hurdle to the producer who wants to market factory-built houses on a nation-wide basis.

Attempts are being made to break this impasse and to set up new criteria. Before the war the National Bureau of Standards, the Forest Products Laboratory, and the various government agencies concerned with housing prepared a set of minimum structural requirements, which was recommended for use by local authorities in modernizing their building codes. Recently the N.H.A. has sponsored a revised edition of this publication. The document is an important step toward the formulation of a uniform national code for house construction, but the burden of proof is still put on those who propose to build unconventionally to show that their proposals will provide adequate safety and quality. In short, there is as yet no fully satisfactory guide for the development and evaluation of factory-built houses using new-type materials.

The lack of desirable performance standards should not be construed to mean that the new factory-built houses are substandard. They are, in fact, distinctly superior to the average conventional house in quality and livability. The difficulty is one of requiring compliance with standards that have become obsolete and consequently wasteful. Many local codes, for instance, specify that house walls must be at least 11 inches thick, even though the structural loads can be handled easily enough by walls only 2 or 3 inches thick when new materials are used. Some localities actually have banned the use of metal walls.

In the past, high factors of safety—three to ten times the calculated loads—have also governed house construction. This was necessary because the materials used—wood, stone, and the like—had to be accepted pretty much as formed by nature. A high allowance for variation in performance was a guarantee that the structure would stand up intact against earthquakes, hurricanes, heavy snowfalls, and other extraordinary happenings. With the introduction of new synthetic materials whose uniformity and quality can be rigorously controlled through inspection in the factory, the need for such large factors of safety disappears. Airplanes are built with factors of safety as low as 1.5 and are well able to withstand even more extreme hazards than are encountered by the average house.

Theoretically, the new structural systems can be engineered to meet any desired range of performance requirements. To make them conform to the standards established for conventional construction is to make a Procrustean demand. Ceilings, for example, are usually required to be so constructed that under maximum loading they will not deflect more than 1/360 of the room span. The reason is that beyond this bending limit plaster is likely to crack, and ceilings usually have been made of plaster. However, if the ceiling happens to be an aluminum skin, it can flex sharply under load and still be able to snap back into its original position without being any the worse. To keep the panel from exceeding the traditional deflection limit, the metal skins would have to be increased in thickness or other structural design changes made, which would increase the cost. New deflection limits are needed, but what these limits should be—1/270 or 1/240 or something less—remains a moot question.

In setting up desirable standards of performance, the task essentially is to predetermine the range of functions a house should serve and then to prescribe the necessary behavior as a control over the development of new materials and structural systems. Findings from many lines of research must be brought together and coordinated. This is in itself a research task of unlimited scope, for the performance standards will constantly change as new advances in science and technology open up new potentials.

The shape of things. Just as the first automobiles were horseless carriages" (even to the extent of having whipsockets) and the first airplanes looked more like kites than "flying machines," it is not surprising that the factory-built houses coming on the market are quite conventional in appearance. Similarly, it is safe to predict that these houses will soon evolve into forms more consistent with the needs of contemporary living and reflecting the greater freedom in design that comes through industrialization.

Some experimental models already show architectural advances. Materials like porcelain enamel encourage the use of soft color combinations, which make the houses pleasantly attractive to the eye. By using flat instead of pitched roofs, producers also are discovering that substantial savings (up to $500 a unit) can be gained. At the same time, by recessing the walls or projecting the eaves to form sheltering overhangs and porches, a more distinctive and livable type of dwelling is obtained.

Unquestionably, the most advanced design developed so far for industrial production is the Dymaxion House, a round, igloo-like structure of aluminum and plexiglas suspended from a central mast and anchored to concrete footings. The circular plan offers the advantage of a maximum of space being enclosed with a minimum of materials, while the tensional construction uses the metal at its strongest capacity. Light in weight (only 3 tons), the house is divided into rooms of variable size by means of large, standardized utility units, which serve also as storage, kitchen, bathroom, and laundry equipment compartments. Each bedroom has its own bath with fixtures stamped integrally out of the partition walls. Anyone who has inspected the full-size prototype in the Beech Aircraft plant at Wichita, Kan., will testify that the curving walls, the ribbon fenestration, and the high room ceilings give a luxurious sense of interior space. Tooling up costs are high for Fuller Houses, however, and little progress has been made since more than a year ago when the experimental house was first publicized. Recent reports indicate that the company is getting new financing and expects to be in production this year.

Another unusual house design is the dressed-up Quonset hut which the Great Lakes Steel Corporation of Detroit has developed in response to requests from ex-G.I.'s who became familiar with its virtues while overseas. In its new de luxe form the Quonset is considerably modified: the familiar half-barrel shape is retained, but side walls are hung perpendicularly from the supporting arches, and end walls are recessed to form porches or glassed-in living rooms. Special windows, flower boxes and trellises, overhangs for walkways and carports, built-in wall cabinets, and other details provide architectural variety.

Exactly what the manufactured house of the future will look like is still a matter of conjecture. In line with Louis Sullivan's precept that "form follows function," Frank Lloyd Wright, Gropius, Neutra, Kiesler, and other pioneering designers here and abroad have been experimenting with new ways of enveloping space. The forms vary widely—they range from rigid geometrical combinations, using the square or the hexagon or some other element as the module of design, to completely amorphous units in which walls curve continuously and indoor space fuses with the outdoors almost indistinguishably.

Some designers have suggested that the house should be split up into separate "space units" for each of the various household activities. These units could then be manufactured individually and hooked up together on the site with "connector units" to form individual dwellings of variable design. Paul Nelson, for example, has developed a "suspended house" scheme, which consists of tall metal columns supporting roof trusses from which walls of glass or plastic,

adjustably transparent or opaque, are suspended; within this large, boxlike shell, essentially a general living room, are a variety of irregularly shaped room units, each an independent structure designed to conform to the requirements of a particular activity (e.g., food preparation, sleeping, bathing, study) but all linked together by spiraling ramps and terraces suspended at different levels. New room units could be added or substituted as desired. The entire structure would provide a three-dimensional, easily alterable flow of family activity.

Underlying all such innovations is the need for more precise information on exactly what are the desirable patterns of family activity. It should be the objective of a comprehensive program of housing research to provide such information. Many elusive factors must be ferreted out and studied, including the subconscious dwelling needs of people, and the psychological effects of color and of various geometrical forms when used as space enclosures for the human organism.

Community development. The more the new dwellings depart from traditional forms, the more imperative it becomes that they be put up in planned groupings rather than as isolated units. No matter how pleasing an individual Dymaxion or Quonset or X-space house may be by itself, it would be jarringly conspicuous if placed in a setting of conventionally designed houses. To show off to best advantage, the new models should be surrounded by others of the same type.

Besides esthetics, straight business reasons call for the organization of dwellings into well-planned neighborhoods or communities. The economies of mass production in the factory must be matched by the savings which come from large-scale operations on the site. Unlike automobiles, radios, refrigerators, and other manufactured goods, the factory-built house is not ready for immediate use when it leaves the plant. It is simply, to use a term already adopted by the emerging new industry, a "package" of prefabricated parts or components that must be put together into a structure and tied to a foundation on a particular area of the earth's surface. Before this structure becomes fully livable, it must in turn be hooked up with various transportation and communication networks, power lines, utilities, and local services. Unless the house manufacturer is willing to do all this site work himself, he must sell his "package" to others who will. This presents a special problem, for the traditional marketing system is geared to serving small local builders who put up only a few houses at a time, usually on scattered individual city lots. Most of the new producers are therefore seeking to sell direct to large-scale builders instead of through the customary channel of distributors, dealers, contractors, and subcontractors, each of whom has to add a sizable profit as compensation for his middlemanning. Buying in quantity, the big builders should be able to pass the economies of factory production straight on to the housing consumer and, at the same time, through efficient site work, add new savings of their own.

To the housing designer, this trend toward mass marketing of houses has important implications. As the government discovered during the war, good housing comprises much more than just houses. When schools, stores, or recreational facilities were lacking, or when too much time was required for workers to travel to their places of employment, housing projects were slow to fill up and sometimes even stood empty despite the congestion of population in war-production centers. The N.H.A. planners had to consider the addition of community services and amenities.

At least one new producer—General Homes, Inc., of Columbus, Ohio—has recognized this basic principle and plans to produce complete community projects as its end product. Not only will it fabricate the

parts for individual structures (using a system of aluminum-surfaced panels with insulated aluminum cores), but it will also acquire land, develop it, and erect the houses, a hundred or more at a time, together with shopping centers, nurseries, parks, playgrounds, and other desirable neighborhood adjuncts. The CIO, which has long been urging this sort of industrial development, is forming mutual home-ownership corporations and housing cooperatives, made up largely of union members, to buy the projects upon completion. The company expects to fabricate and build 1,700 aluminum houses this year and 10,000 or more in 1948.

When housing is viewed as an integral part of the problem of planning neighborhoods and communities, it becomes clear that individual dwellings should be designed to conform with the most desirable patterns of community activity as well as individual family activity. What these larger patterns should be—the interrelationship between the house and other structures in the community—is a matter that likewise calls for scientific investigation. We have as yet very little coordinated information to serve as standards of performance in community development.

Our cities and towns have grown by stretching haphazardly out into the countryside, leaving the older central areas to wither and rot. The gridiron streets and blocks, originally intended for horse-and-buggy transportation, have been long outmoded. Only with great difficulty and at large cost have a few new auto highways been superimposed to relieve the traffic bottlenecks. The airplane brings new planning difficulties before the older ones have been solved; time saved in flying across country is lost in going from the local airport to the office or home. Further anachronisms are bound to arise when people begin traveling in rockets at supersonic speeds.

This implies a program of housing research on the broadest possible social scale. Changing needs in other fields of human activity—communication, education, recreation, health, sanitation, power, manufacturing, farming, business, finance, and so on—should likewise be studied to determine the effects they will have on the functional requirements of the house and the community. The lengthening of the educational cycle to include very small children at one end and older adults at the other, for instance, raises the question of how far these new needs should be provided for in the home and how far in other community structures.

One of the most pressing problems is the question of health raised by current happenings in the housing field itself. Approximately 35 percent of the houses now being built in this country are going up on outlying land beyond the reach of municipal water-supply and sewage-disposal systems. This percentage is expected to double within the next year as builders find it increasingly difficult to obtain suitable land at reasonable prices inside the city limits and are forced to go farther and farther out. In doing so, they must rely largely on cesspools and septic tanks. Fortunately, the N.H.A. is aware of the sanitation hazards and, in collaboration with the U. S. Public Health Service, has launched a research and testing project aimed at improving the design of individual sewage-disposal systems.

It should be noted that our use of water as a carrier of household and industrial wastes is very wasteful. Not only is there the problem of pollution, which makes it necessary for the next community downstream to purify the water for drinking purposes before it in turn adds new pollution, but the present per capita consumption of water is excessively high (about 30 gallons daily, of which only 1 gallon is used internally). If our sanitary equipment were more efficiently designed, the average American home could get all the water it needed by merely con-

densing it out of the atmosphere as part of the air-conditioning system. To this end Buckminster Fuller, the Dymaxion designer, has proposed the use of water-saving "fog guns" for bathing and dishwashing, and the elimination of sewage by electronic heating, which would evaporate the liquids and leave a dry, easily removable ash. A utility-service unit combining equipment of this sort with an individual low-cost power plant would make the house mechanically independent of the city. Dwellings could be placed wherever desired.

Sanitation is only one of many health factors that must be considered by the housing designer, however. The house must be made as hazardproof as possible. Even more important, it must be designed to be an instrument in promoting good health, mental as wel as physical. As a guide in such work, the American Public Health Association's Committee on the Hygiene of Housing has undertaken to set up standards of healthful housing; a report analyzing desirable features in the neighborhood environment of dwellings is now in preparation and will be published soon.

Similar broad approaches to the problems of housing and community development should be made from other directions. Any contradictions or conflicts in the standards set up by specialists in the various fields would immediately indicate the need for further specialized research. Properly coordinated, the program of housing research would be self-generating.

Expanding horizons. The outward push of our cities, long evident and now accelerating in a potentially enormous burst of housebuilding, presents sharply the question of what should be done with the obsolete central areas. Urban blight is certain to widen and intensify as people move into new homes in the satellite communities springing up on the outskirts. The older developments cannot be left to become ghost towns.

This problem has already come to the attention of the nation's lawmakers. The Taft-Ellender-Wagner general housing bill provides that the Federal government shall extend substantial financial aid to localities for the acquisition and redevelopment of blighted areas. Obsolete structures would be demolished, new street patterns laid out, and the land made available for parks, playgrounds, airports, housing projects, business buildings, factories, or other new uses. Unless adequate planning safeguards are set up, however, the new construction is likely to fall again into eventual blight and decay, so that the expensive cycle of acquisition and redevelopment will once more have to be repeated. It is the responsibility of a properly planned program of housing research, as a service to future generations of taxpayers, to see that this does not happen.

The issue is not centralization versus decentralization, but rather mobility versus stagnation. Traditionally, we have insisted on a fixed pattern of growth for each locality—like Major L'Enfant's famous "plan," which has crystallized into the traffic-snarled congestion of downtown Washington, or Ebenezer Howard's dream of self-sufficient "garden cities," which has been translated into a Letchworth or Welwyn existing only by virtue of its economic dependence on metropolitan London. As instruments of social growth, communities are constantly being changed in size and character by the very advances which they themselves help to create. Ever-changing, expendable, even ephemeral in instances, each must develop according to a variable rather than a fixed pattern of growth. Furthermore, each must be looked on not as an isolated local phenomenon but as an integral part of a region-wide, nation-wide, even world-wide mosaic of continuous change.

This concept of planning means that the development of any form—from the simplest tool to the most complex metropolis—cannot be considered complete until it has

been eliminated in favor of more desirable forms. The objective is increasing productivity—the continuous development of new forms which can be used as specific means for specific needs. But, unless there is a tie between the elimination phase and the research phase, there will not be a harmonious continuity of development. The obsolete must be removed to make way for the new. A system of time-zoning is needed to ensure the orderly elimination of obsolete structures.

In short, an increasing number of persons and things and ideas must be brought into working unity on the problems of research in the housing field. The facilities for such cooperation are still largely lacking, however. A few educational institutions—Purdue, Harvard, the University of Illinois, the University of Michigan, and the Bemis Foundation at M. I. T., for example—are doing notable research in housing, but this work has been on an insufficient scale and without benefit of a central plan. As Senator O'Mahoney's Temporary National Economic Committee found after extensive hearings in 1940, there should be an agency within the government, similar to the National Advisory Committee for Aeronautics, with ample funds to sponsor a coordinated program of technical research in housing on a scale broad enough to meet the nation's needs. A bill authorizing the N.H.A. to assume this responsibility was introduced two years ago by Senator Kilgore and Senator Wagner. Its provisions have been absorbed into the general housing bill recently before Congress. To combine the broader social approaches with such technical research in housing and community development should, of course, be among the functions of a National Science Foundation.

With proper organization for research, the horizons are indeed unlimited. Man has already come a long way as a designer of environment. From the poor harried troglodyte who could do little more than kindle a fire and pile up some rocks outside his cave as a barricade against other marauding animals, he has advanced to the point where he has the potentials and resources to fashion any kind of habitat he may desire. He has penetrated the stratosphere and is thinking about traveling through outer space. He communicates instantaneously around the world. He watches events while they are happening far over the horizon. He has even produced power as great as the sun's. Deftly he manipulates the invisible, the inaudible, the intangible.

Man's further development depends on his increasing his control of environment—physically, economically, culturally. With such control, an increasing surplus of human energy can be released from the restrictive forces of an uncontrolled environment. This surplus—leisure—becomes available for the creation of even more desirable forms, an infinite variety of forms that man can use for his own good. It is an exciting thought that man, as an evolving form of life, has only to determine, before proceeding to produce, the kinds of environment he needs to promote and guide his own evolution.

THE ROLE OF CONVENTION BUREAUS IN A.A.A.S. MEETINGS

THE BOSTON CONVENTION BUREAU AND THE 1946 MEETING

By JAMES A. MORRISON

Manager, Convention Bureau, Boston Chamber of Commerce

THERE are 44 cities in the United States that maintain convention bureaus either as individual civic agencies or as departments of local chambers of commerce. These bureaus have annual operating budgets ranging from $15,000 to $100,000 a year, depending on the size of the city and its importance in the convention field. The funds subscribed to maintain convention bureaus come principally from obvious sources, such as hotels, restaurants, retailers, utilities, taxicab companies, purveyors, and suppliers.

In normal times keen competition exists among the principal cities of the United States for the convention visitor's dollar. We want and need conventions in Boston because they bring some seven to eight million dollars in new money into the area each year—money that has been earned in other cities and states.

One month after our Convention Bureau in Boston was reopened in November 1945, it came to our attention through the local press that the A.A.A.S. would hold its first postwar convention in St. Louis March 27–30, 1946. Upon reading this announcement, I pulled out our file on the A.A.A.S. and found that twelve years had elapsed since the Association had last met in Boston, December 27–30, 1933. Because of this long interval, the probability that an east-coast meeting would follow a midwest meeting, and the fact that James B. Conant, of Harvard, was the 1946 President, we felt we had a very strong case to present in behalf of Boston.

In order for Boston to be officially considered by the A.A.A.S., the first and most important job of the Boston Convention Bureau was to secure the active support and endorsement of a Boston convention bid by the nine member-institutions of higher learning in this city.

Our first step was to write to the presidents of the nine local universities, which are as follows:

Boston College
Boston University
Harvard University
Massachusetts Institute of Technology
Northeastern University
Radcliffe
Simmons College
Tufts College
Wellesley

The college presidents unanimously endorsed our proposal to bring the 1946 December meeting to Boston, and as a result an official convention invitation committee was set up with one representative from each of the nine schools.

Under the direction of this special committee, the Convention Bureau then prepared a personal leather-bound brochure of invitations to the Executive Committee of the A.A.A.S. containing official letters of invitation from the Governor, the Mayor, the presidents of the nine local universities, local scientific organizations, and the commercial interests such as the Chamber of Commerce and the hotel association. This brochure gave to the Executive Committee full assurance that Boston would heartily welcome the scientists' convention and would meet every requirement, including

meeting halls for 60 simultaneous sessions, an exhibit hall for the Scientific Exhibition, and some 4,000 hotel rooms. Many hours of detailed effort went into the preparation of these personalized invitations.

The decision on the location of the December 1946 convention was to be made in St. Louis by the Executive Committee. It was necessary for the Convention Bureau Manager to attend the Executive Committee meeting in St. Louis to present personally Boston's bid. The decision of the committee was unanimous for Boston, although many of the members could recall their last visit here in 1933 when the city experienced one of the worst blizzards in its history, with temperatures at twenty below zero. Fortunately, those memories of Boston weather did not affect the final decision.

With Boston now definitely set as the place for the 1946 Annual Meeting of the A.A.A.S., the work of the Convention Bureau was actually in its initial stages. Our first job was to poll the 41 hotels in the city to secure a blanket reservation for all their transient hotel rooms for the dates of December 26–31, 1946, in the name of the A.A.A.S. At the same time it was necessary to secure some 60 meeting rooms in hotels and in clubs, churches, and schools that were conveniently located to the hotels in which the delegates would be staying. I know of no convention that places a heavier demand for meeting space on a city than the "four-ring circus" of the A.A.A.S. In Boston 35 of the meeting rooms were located in our local hotels; the remainder were placed in university buildings and private institutions.

From the first of October until the date of the meeting, our office served as a housing bureau for the convention. Over 3,400 requests for hotel reservations were handled by a staff of secretaries. Each reservation required at least two letters, one to the visitor and one to the hotel. Allocating hotel accommodations for three to four thousand people is a man-sized job.

Of course, throughout the year it was necessary for the Bureau Manager to attend many of the meetings of the local Committee on Arrangements. Among the obligations the host city must assume is the raising of an entertainment fund of some $3,000 by this Committee on Arrangements. In Boston this fund was subscribed largely by the local universities, with some assistance from commercial laboratories and industries. Harvard University provided special entertainment for the visitors, including a concert by the Harvard Glee Club. The Entertainment Committee also secured some 2,000 tickets for a concert of the Boston Symphony Orchestra. These were distributed without charge to our visitors.

When the meeting was about to open, it became the responsibility of the Convention Bureau to register the visitors. This required a staff of 14 girls for three days, 18 typewriters, and an elaborate Kardex filing system so that one could locate in Boston any one of the registrants.

The week between Christmas and the New Year is normally the point of lowest occupancy for local hotels. Traveling men have all gone home for the Christmas holidays. The dates of the annual convention of the A.A.A.S. therefore come at an ideal time, providing capacity business for hotels and restaurants at a period that would otherwise be the poorest week of the year. A detailed survey showed that in excess of $60 per person was spent by each out-of-town visitor to the A.A.A.S. Convention—a quarter-of-a-million-dollar plum for Boston. In addition to the monetary value of the Meeting, it draws more national publicity than any other convention in the United States. The convention was on the front page of the *New York Times* each day with a Boston date line; *Time* and *Newsweek* each ran a full page. There were some 78 science writers from newspapers throughout the country who personally covered the Boston meeting.

In conclusion, it is important to emphasize the need for carefully examining the facilities available for the A.A.A.S. in future convention cities. In my opinion there are not more than six or eight of the larger cities in the country that can properly accommodate this large gathering of scientists. To avoid conflicts with meeting dates of other educational associations that hold their conventions during Christmas week, we who are Managers of the Convention Bureaus would like to see your Association set up a long-range program of meeting locations for at least five years ahead. Certainly the schools, colleges, and business interests of Boston would be glad to welcome the return of your Association at the very first opportunity.

NOTES ON THE CHICAGO MEETING, A.A.A.S.

(*Continued from page viii*)

(L) *History and Philosophy of Science* sessions will include a symposium on "The Foundations of Modern Physics" Saturday morning, December 27, and, in the afternoon, a discussion of the "Problems of Concept Formation in Psychology." A Sunday afternoon session on social concepts has been arranged.

(M) *Engineering*. Section M will meet Tuesday, December 30, at the Sherman Hotel, with the *Limnological Society of America*, to discuss "Limnological Aspects of Water Supply and Waste disposal." Theodore A. Olson, School of Public Health, University of Minnesota, will be chairman of this meeting. Section M will also meet on Monday, December 29, to discuss topics of general interest.

The American Society for Horticultural Science will hold sessions in the Palmer House each morning from December 29 through December 31 for the reading of papers on pomology, floriculture, and vegetable crops. On Monday afternoon, December 29, there will be a joint meeting with the *American Society of Plant Physiologists* at which a symposium on "Dormancy in Plants" will be presented. J. P. Bennett will be chairman. In the evening there will be three round-table discussions: "Methods of Breeding Horticultural Crops," G. M. Darrow, chairman; "Mineral Deficiency Diagnosis," D. Boynton, chairman; and "Methods in Extension Work." Tuesday afternoon the Section on *Agriculture* (O) will meet with the Society to discuss "Breeding Horticultural Crops." W. S. Alderman will be chairman. The Annual Banquet of the Society will be held Tuesday evening. On Wednesday morning, December 31, there will be a joint session of the Society and the *Potato Association of America*, at which papers on pomology and floriculture will be read. The annual business meeting will be Wednesday afternoon.

The *American Society of Parasitologists* will hold six sessions (all morning or afternoon meetings) December 29–31. No joint sessions with other societies have been planned.

The American Society of Zoologists will hold its Annual Meeting in Chicago December 29–31. On each morning there will be general sessions for the reading of papers. The afternoons of December 29 and 31 will be devoted to symposia sponsored jointly with several other biological societies. On Tuesday afternoon, December 30, there will be a demonstration program at the laboratories on the campus of The University of Chicago. At the Zoologists' Dinner to be held in the Blackstone Hotel on December 30, Dr. Franz Schrader, vice-president of the Section on *Zoological Sciences* (F), will speak on "Three Quarter-Centuries of Cytology."

The Botanical Society of America is planning twenty-four sessions for December 26–30. General botany, physiology, microbiology, phytopathology, mycology, taxonomy, morphology, and plant anatomy will be discussed in various meetings with associated societies such as the *American Society of Plant Physiologists*, *American Society of Plant Taxonomists*, *Mycological Society of America*, *The American Phytopathological Society*, *Ecological Society of America*, and the *American Society of Naturalists*.

CHILD LABOR OF THE TERMITE SOCIETY VERSUS ADULT LABOR OF THE ANT SOCIETY*

By CLARENCE HAMILTON KENNEDY

Dr. Kennedy (Ph.D., Cornell, 1919) has had a long and distinguished career in zoology and entomology. He has been at Ohio State since 1919 and has been Professor of Entomology there since 1933. Although the essential literature on the social insects is widely scattered, we were forced by limitations of space to omit the careful bibliography prepared by Dr. Kennedy.

IN COMPARING the pattern of termite social organization and behavior with the very different behavior and social organization of ants, we find almost at once that the termite society is operated on child labor, whereas the ant society is operated on adult labor. Students of the societies of insects, which form of life has arisen independently many times, as evidenced in the termites, beetles, ants, bees, and wasps, point out that the society of the termites is weak and continuously on the defensive, whereas that of most ants is vigorous and continuously on the offensive. Termite literature abounds with the opinion that ants are the termites' worst enemies. There are reasons why.

Limited by space and the reader's time, this discussion will cover only three of the more than a dozen species of Reticulitermes distributed in the Orient, about the Mediterranean, and across the United States. These of the family Rhinotermitidae have the pattern of organization and behavior of the higher termites but lack the high specializations of the tropical Termitidae. In ants, more diverse forms will be considered. I have made no original study of termites but I have been much interested in them in comparison with the organization and behavior of ants, which societies I have studied many summers. The present knowledge of American termites is based on the studies of Nathan Banks, T. E. Snyder, A. E. Emerson, S. F. Light, and A. L. Pickens.

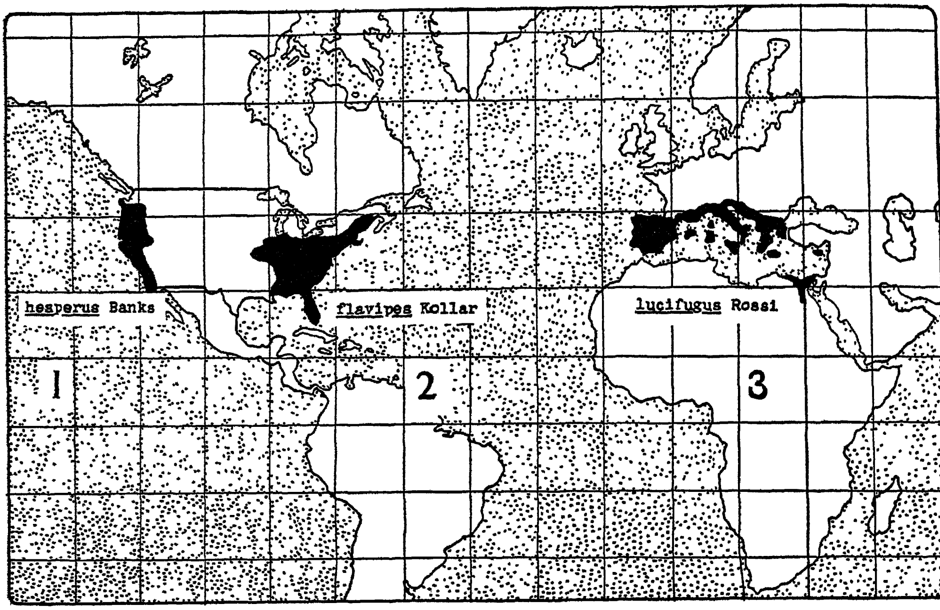
Fortunately for our knowledge of termites, the distribution of some of our most destructive forms of Reticulitermes, in the North Temperate Zone, coincides rather exactly with the greatest density of zoologists and entomologists. Such seldom have to go much farther than their own woodsheds and garages to locate laboratory material. In Europe there is one species, *lucifugus* (Figs. 1–3). In America there are about a dozen species. Two, *flavipes*, of the Eastern states, studied by Banks, Snyder, and Emerson, and *hesperus*, of the West Coast, studied by Light and Pickens, are the better-known forms. Their habits are so similar we will not distinguish between the two.

Reticulitermes rates as a subterranean,

* This article was presented December 26, 1946, as a lecture before the Cambridge Entomological Club as part of the Christmas A.A.A.S. program.

This comparison and concept was worked out, and part of the figures were drawn, at the University of Michigan Biological Laboratory, Douglas Lake, where the author was registered as an "Investigator" (of ants) in the summer of 1946. It was completed at Ohio State University.

It was initiated as a review of the present knowledge of instars and castes in termites and ants. The study shifted to the relationship of these to social physiology, which soon became the problem of immaturity in the termite society versus maturity in the ant society. Only casual references to this difference were found in Wheeler's writings. Dr. Theodor Just suggested that Wasmann had published on such a point of view. This was finally located (Wasmann, Erich. Die Democratie in den Staaten der Ameisen und der Termiten, Bd. X, *Forsuchungen zur Völkerpsychologie und Soziologie,* 1931, 309–336). His discussion is from the point of view of polymorphism, a factor not introduced in the present article. The best review of polymorphism is in Wheeler, Wm. M. *The Social Insects,* 1928, (VII, VIII), with full references to 1928.



FIGS. 1–3. DISTRIBUTION OF THREE SPECIES OF RETICULITERMES

AMONG THE MOST DESTRUCTIVE OF TERMITES, THESE SPECIES HAVE BEEN STUDIED MORE THAN OTHERS.

or ground, termite. It has to have contact with damp soil to obtain moisture. If this contact is maintained, the colony can then burrow into aboveground wooden structures. Reticulitermes eats wood. Figures 4–6, from S. F. Light, show a nest in the framework of a dwelling where the colony may have entered through the exploratory tunnel at the lower left or from the infected stump at the lower right. The latter connection has a covered way (Fig. 6) over the concrete foundation.

Softer parts of the wood are eaten first, but finally all parts are destroyed except the walls of the nest. Always the nest is completely invested with an antproof outer wall, which is usually of the original wood; at times it is built of a cement of soil, frass, excrement, and salivary secretions. This wall is opened only at tunnel heads when the galleries are extended and once or twice a year for the emergence of the adult winged males and queens. The simple-minded worker termites survive in a vicious world by shutting themselves away from the overpowering problems that would arise if they had to struggle with the external environment. Like children in human society, they live in the house. They are without the adult vigor of structure and behavior that would save them in the outer world.

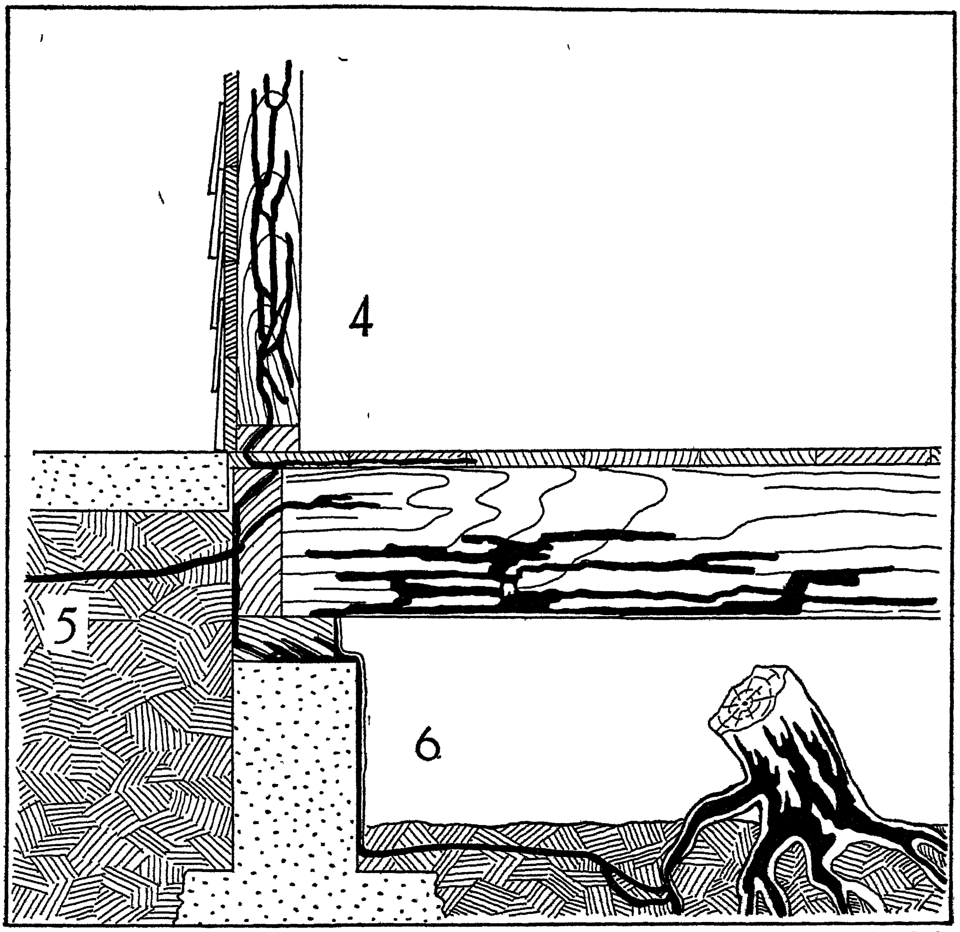
Wood, which termites cannot digest, is also their food. The intestine of the young of all castes, and of the workers throughout life, is packed like a sausage with large flagellate protozoa (Figs. 7–12), which are of special flagellate families that apparently have evolved in the termites and in some roaches. The protozoa digest the wood, and the termite host absorbs the products of digestion. A termite in excellent health will carry his own weight of protozoa.

Protozoa are thus an essential part of termite social economy. The active young termite just hatched is without them, though it can eat regurgitated, or stomodeal, food from the mouth provided by the older young and the workers. In its second instar it is fed proctodeal food from the anus of the workers, which liquid contains the living protozoa necessary to the termite's well-being. These protozoa multiply with great

rapidity and soon pack the young termite's intestine. The process of infection has to be repeated after each ecdysis, or shedding of the exoskeleton, at which time the protozoa are evacuated.

Because of their great, toothless jaws, mature soldier termites cannot chew wood. They are fed by mouth on stomodeal food regurgitated by young termites and workers, which have wood-chewing jaws with teeth. The same is true for the matures of the three reproductive classes, which have good jaws but degenerate jaw muscles. Thus, in later life, when fully developed, the soldiers and reproductive castes have to be fed by the young and workers, so that they get along with few or no protozoa. The flight queen is limited to a few protozoa since she cannot carry many and be light enough for easy flight; but she has to carry a few to infect her first young.

The food habits of Reticulitermes offhand appear very simple as the society is established in a home of indefinite extent, which at first is also a mass of food. They eat their own wooden house but because they, like all other animals, require proteins, carbohydrates, fats, various salts, and vitamins, an exclusive wood diet is an incomplete diet (Fig. 13).

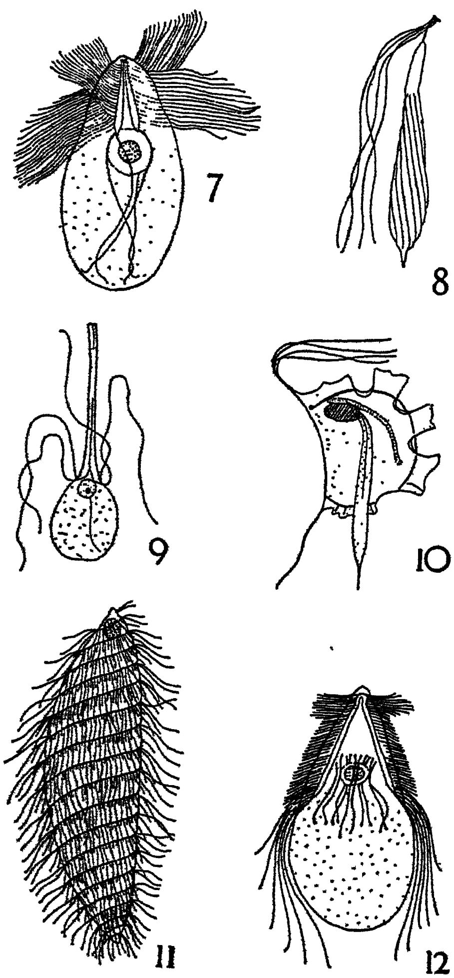


From S. F. Light

FIGS. 4–6. HOW TERMITES MAY ENTER HOUSE TIMBERS

(4) NEST GALLERIES OF RETICULITERMES IN A HOUSE. (5) ENTRANCE TO HOUSE BY EXPLORATORY TUNNEL OR FROM THE STUMP AT RIGHT. (6) COVERED WAY OVER THE CONCRETE FOUNDATION.

The matter of carbohydrates is solved through the transformation of the cellulose content of wood into usable sugars by the protozoan fauna of the termite intestine. It does not appear to be known whether the protozoan is "diabetic" and after digesting wood within its body excretes sugars into the termite gut, or whether the digestion of wood may be external to the protozoan by enzymes secreted by it into the sawdust-filled termite intestine. Fragments of evidence suggest both forms of wood digestion, and evidence points to an abundance of this type of food.



From Harold Kirby Jr.

FIGS. 7-12. PROTOZOA FROM TERMITES

THE FOLLOWING FLAGELLATES ARE EXAMPLES OF PROTOZOA THAT LIVE IN THE ALIMENTARY TRACT OF TERMITES AND DIGEST THE WOOD (CELLULOSE) CONSUMED BY THESE INSECTS: (7) STAUROJOENIA, (8) STREBLOMASTIX, (9) OXYMONAS, (10) TRICHOMONAS, (11) HOLOMASTIGOTES, (12) TRICHONYMPHA.

Theoretically, the problem of fats appears simple and follows on the abundance of carbohydrates. Nearly all young insects and young mature female insects, as is shown by the presence of fat bodies, must elaborate fats easily. This fact of a youthful digestion in a land of wood and sugars might well be why, in the termites, evolution appears to have favored immature forms for the bulk of the societies' household labor. Such physiological advantages and also limits are not directly visible, but we know they direct or limit evolution as vigorously as do structural elements.

The great problem in termite nutrition is that of a supply of nitrogen to build amino acids, which build proteins, which build protoplasm in its many body forms. The animal is a protoplasmic energy-transforming mechanism. Nitrogen is a must. One suggestion is that wood harbors much fungus mycelium, so that proteins may be derived from such fungus sources. This surmise is strengthened by the ease with which many of the higher tropical Termitidae have shifted to fungus for their major food supply.

A second possible source is the fixation of nitrogen from the air by some of the various bacteria that are associated with the protozoa in the intestine, but research has not identified such bacteria.

A third source may be the protozoan bodies evacuated from the young termite at the end of each growth stage. These are shown to be eaten by friends as part of the termite's general fecal diet. All feces are eaten and re-eaten, perhaps for traces of protein. A known source of protein by social conservation rather than from sources extraneous to the society is tapped by the habit of eating all corpses. None is wasted. In human society the habit of eating human flesh, not uncommon among savages, is gen-

erally classed as primitive and is associated with an immature stage in social evolution. Such reasoning tends to class termites as immatures.

Another habit of various social insects is similar and, while broadly a conservation of protein, is also a resource in any food shortage. It is the consumption of their own eggs and infants. In termites the conditions that produce infanticide are not known, but shortage of proteins appears more probable than one of wood. With babies, termites toss in the cripples and the ill, which are usually eaten a bite at a time as they drag about the colony. This again is an undifferentiated or immature type of behavior.

The practice of cannibalistic infanticide in termites, ants, and some semisocial Coleoptera appears to support Wheeler's theory that trophallaxis, or the exchange of regurgitated food and various secretions between mother or nurse and young, is the binding force in the insect nursery. Whatever the social binding force may be, it is obvious that it does not stand the heavy social strains of selfish individualism, because termites eventually eat one another. This circumstance suggests that it is not psychic, as in the vertebrate family and society. In the vertebrate nursery household difficulties usually tend to intensify mother love and the related psychic bonds that hold mother or nurse to the young. The vertebrate mother tends to defend the lives of her young even to her own death. Trophallaxis never exhibits the social binding force characteristic of the psychic mechanisms of the large vertebrate brain.

Snyder's observations on the annual flight of the winged royalty suggest another source of reserve protein. In Reticulitermes at the time of the great annual flight of winged first-form reproductives, that of the royal kings and queens, there is also produced a secondary swarm of second-form reproductives, those with wing pads only. These have served as child labor, then have evacuated their protozoa to become reproductives, social liabilities, as they have to be fed by the laboring classes. At the time of the great flight they disappear as suddenly as they have appeared. They may each, with a male attendant and loyal workers, have dug away from the home nest to establish new nests without ever having had a nuptial flight. If so, evidence of such new nests in numbers about the home nest has not been found. A few remain in the home nest and are responsible for the great populations of mature colonies. But the majority are merely excess royalty. Our own suggestion is that their plump, royal bodies may provide protein at an annual feast of the laboring classes.

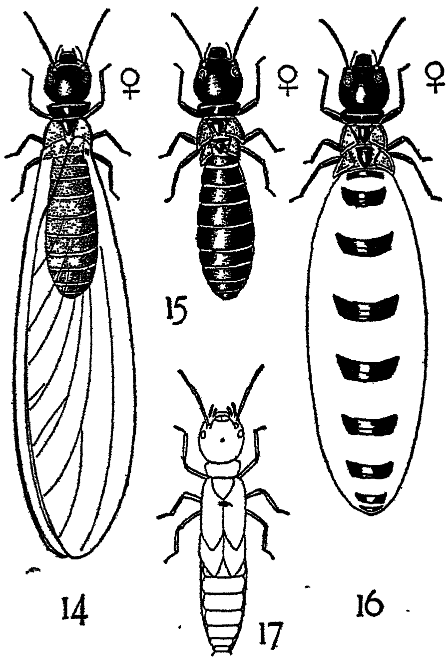
Food Used by Termites

1. *Carbohydrates:* from wood.
   Cellulose converted to sugars by intestinal Protozoa.
2. *Fats:* from sugars, and
   from fatty exudates lapped from body surface of friends.
3. *Proteins:*
   Original: From fungus mycelium?
   From intestinal nitrifying bacteria?
   From protozoan bodies?
   Conserved: By eating the dead and injured.
   By eating eggs and young in emergency.
   2nd and 3rd form queens eaten?
   By proctodeal food containing dead Protozoa.
   By eating feces containing dead Protozoa.
   By a nitrogen cycle: Malpighian urates used by intestinal Protozoa and these by the termites.
4. *Stomodeal food:* Predigested food from the mouth. Probably mostly sugars but with other elements.

FIG. 13. TERMITE FOODS

Leach and Granovsky have suggested a nitrogen-conserving cycle by which the nitrates from the termite are discharged into the protozoan-filled intestine directly from the Malpighian tubules. The nitrates would be used by the protozoa, which would then be eaten by friends in their general fecal diet. The regular use of a fecal diet strongly suggests that it contains nitrogen and perhaps vitamins.

The present positive knowledge of the domestic economy of termite society is, as you have read, a wonderful tissue of intriguing assumptions. This knowledge has but few data that are positive enough to be cheering, such as wood for daily meals, with cannibalism, infanticide, and a side diet of fecal matter. Eating is at the low level of an internment camp where adult, restrained table behavior completely disappears. It is childish behavior at its lowest. In a world of skilled adult socii Emily Post would disapprove of nearly every move a worker termite might make. All would be beneath her mature, adult dignity.



Redrawn from papers by Snyder

FIGS. 14–17. THE TERMITE QUEEN

(14) VIRGIN ROYAL, OR WINGED, QUEEN. (15) SAME WITH WINGS SHED. (16) SAME AFTER SOME YEARS; ABDOMEN ENLARGED WITH EGGS AND FAT. (17) LAST, OR SIXTH, NYMPHAL STAGE OF A ROYAL WINGED QUEEN. THE ROYAL MALES ARE SIMILAR TO THE ROYAL QUEENS (FIGS. 14, 15, AND 17) EXCEPT FOR MINUTE DIFFERENCES AT TIP OF ABDOMEN. WITH AGE THE MALE IS MUCH AS IN FIGURE 15 BUT IS THINNER IN THE ABDOMEN AND BECOMES HUMPBACKED.

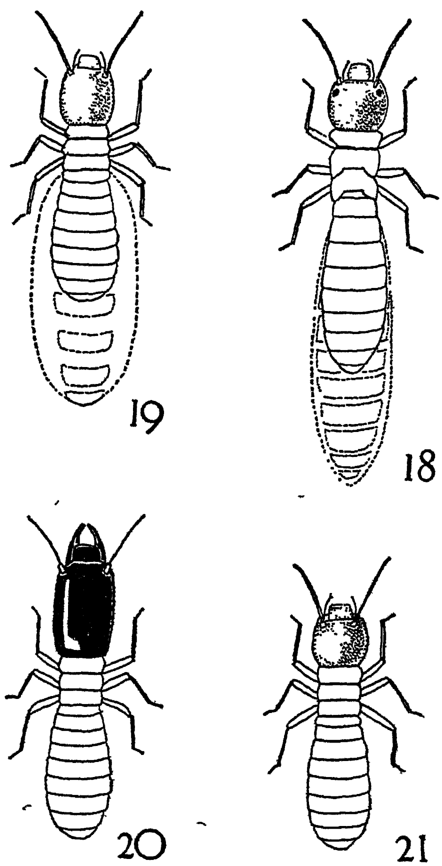
In a nest of Reticulitermes, if lucky, we might find five castes—workers, soldiers, winged royalty, and two grades, or castes, of complemental royalty, one with wing pads and one little different from workers, as its members have not even wing pads. The vast population of tens of thousands in a large nest will be pale-white workers, shown in Figure 21 at the lower right corner. These are of two sexes but are sterile. All castes have equal numbers of both sexes, with the possible exception of the two castes of complemental reproductives, which are usually polygamous; sometimes a dozen or more queens live with one male. About every tenth individual in the scurrying hordes will be a large-headed, long-jawed soldier (Fig. 20). The other five items are queens; reading from the left, Figures 14–16 are of a virgin winged queen of the last, or adult, instar. The black queen is the same with her wings broken off after mating. The very large wingless queen, third from the left, Figure 16, is again the same royal queen after several years, when her abdomen has enlarged with fat and eggs. Not shown is the winged male, which resembles the winged queen and which, later, without wings, resembles the young queen (Fig. 15). No change in his size takes place with age, though as he grows older he becomes humpbacked. Figure 17 is a last-stage nymph of a winged queen or king.

The queen (Fig. 18) at the upper right is a second-form reproductive, recognizable by the short wing pads. After she has mated with a similar or other form of male, her abdomen finally enlarges, as is indicated by the dotted lines. Snyder thinks that queens

of this second reproductive caste carry the main burden of egg production in mature colonies. He has found that a second reproductive form in a few weeks will produce as many eggs as the royal winged queen during her first year. But it must be remembered that during the first year in a royal nest, which, with king, queen, and half a dozen workers, is still a family rather than a teeming society, all developmental processes are at a low energy level without the stimuli of the later great mobs of individuals. Apparently the second-form reproductives boost the population hurriedly when times are good.

The queens of worker form (Fig. 19), without wing pads occur in some nests. Less is known about their age in number of instars, their position and function in the society. They would appear to be one instar below those queens with wing pads. However, termite specialists determine maturity in all three forms of queens by the loss of the two minute anal stylets, a loss which marks sexual maturity in the winged royal queens. The number of instars for reproductives is stated variously as from seven to ten.

Compare the winged queen (Fig. 14) with that with wing pads (Fig. 18), with that without wing pads (Fig. 19), and finally with the worker at the lower right (Fig. 21). Structurally, excepting the loss of stylets, the second and third queen types resemble the worker more closely than they resemble the winged queen. They are wingless and resemble immature forms. Their habits are household habits. They do not face the external environment except for a short time at the annual flight, when some of them come out and try to fly. Contrasted with these who face the environment on wings, they have the fear of it characteristic of all immature forms of the colony. In spite of reproduction they have the behavior of the immature. Present evidence has not yet given fully confirmed data that the wingless reproductives are at full growth in some lower instar than that of the royal pair. Their general body structure suggests fewer instars. They are immature or childish in major characters of structure and are immature in their household behavior. (See Thompson, 1916, and Thompson and Snyder, 1919 and 1920.)

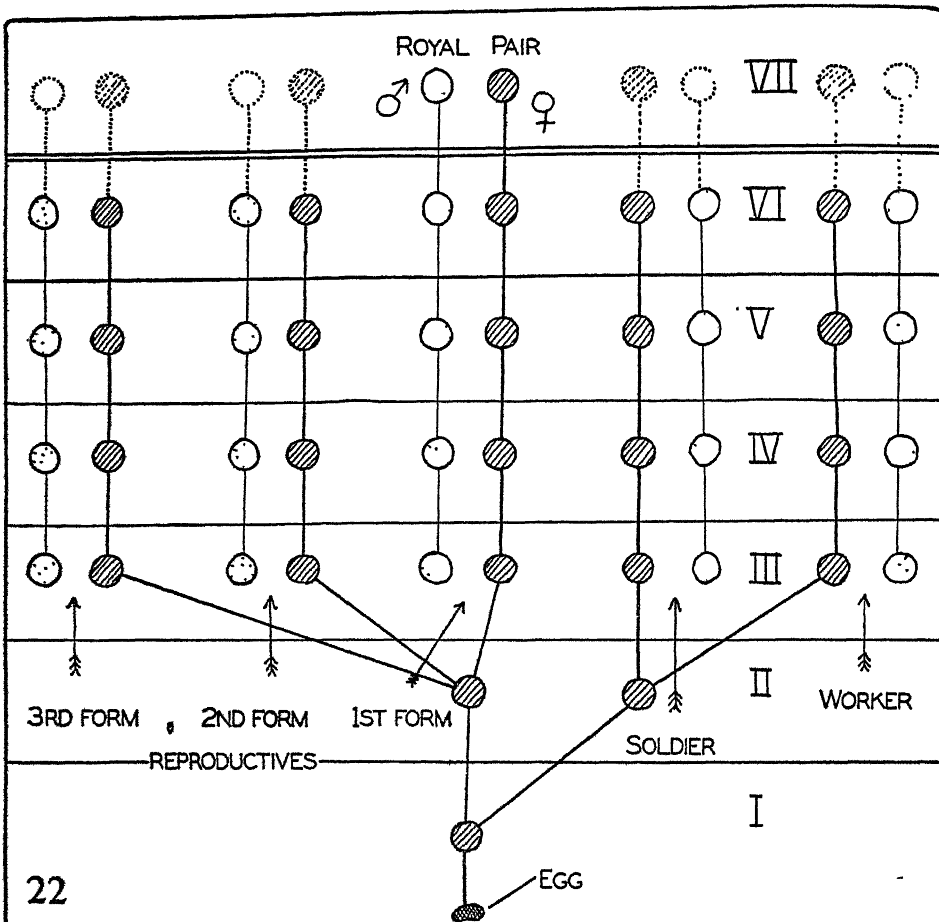


From papers by Snyder, Light, Kofoid, Pickens

FIGS. 18–21. VARIOUS FORMS OF TERMITES

(18) SECOND FORM OF QUEEN WITH PARTIALLY DEVELOPED WING PADS; SECOND-FORM MALE IS SIMILAR. (19) THIRD FORM OF QUEEN WITHOUT WING PADS AND WITH THE APPEARANCE OF A WORKER; THIRD-FORM MALE IS SIMILAR. DOTTED CONTOURS SHOW ABDOMEN OF THE QUEENS WITH ADVANCING AGE (CF. FIG. 16). (20) SOLDIER. (21) WORKER, WHICH IN ALL INSTARS IS NYMPHAL IN STRUCTURE.

The worker is immature in so many structural and physiological characters that we can term it an immature even if it passes through as many instars as the winged



From Escherich, used in Les Termites *by Hegh*

FIG. 22. ONTOGENETIC CHART OF PROBABLE NUMBER OF INSTARS OF TERMITES

INSTAR VI ADDED BY THE PRESENT AUTHOR, AND (DOTTED IN) POSSIBLE "ADULT" INSTARS OF SECOND- AND THIRD-FORM REPRODUCTIVES, SOLDIERS, AND WORKERS.

royalty. It is immature in its wingless structure, it is immature in its childlike housed-in habits, and it is immature in its sexual sterility. The nymphs and older nymphlike workers constitute the great bulk, the tens of thousands, of the colony. There are ten to each soldier and thousands to each reproductive. They give the broad, nymphal picture of the colony's nymphal structure and nymphal behavior.

Some of these points of life history are shown in a widely used chart (Fig. 22) first drawn by Escherich on data from Grassi, the great Italian zoologist, and reproduced here from *Les Termites* by Hegh, the Belgian Congo specialist on termites. Recent studies of Reticulitermes have necessitated the addition of a sixth instar below the double line. Light dots are males, black dots females, since both occur in equal numbers in each caste column. Some of Snyder's data suggest that all castes have an equal number of instars, but other observations by the same author indicate extra skins, shed with little change of form, after the sixth instar. Pickens has suspected that small soldiers in young colonies may be mature in the fifth instar. Thus a suspicion is creeping into discussions that the number of skins shed during growth may vary at times. Evidence is

accumulating to indicate that the number of instars may vary in individuals in other of the more primitive orders of insects.

All first-instar nymphs appear alike, and the same is true for the second instar. During the latter stage the young are fed proctodeal food and become infected with protozoa. Among nymphs of the third instar a skilled specialist can recognize those that will become soldiers. In winged royalty, wing pads appear at the sixth instar (Fig. 17), and apparently all queens become recognizable by plumper bodies than those of workers and by a lighter color, owing to a change to stomodeal food away from the earlier dark, wood diet. The protozoan fauna is greatly reduced, and the anal stylets are lost. This loss of stylets suggests that the second reproductives (with wing pads) and the third reproductives (without pads) at sexual maturity may be in the same instar of development as that of the mature winged royal queens, which are rated variously as in the seventh to tenth instar.

The termite colony is a society built on, and made possible by, incomplete metamorphosis. In insects with incomplete metamorphosis the young are active from the time they hatch from the egg (Fig. 23). Each hustles its own living. The mayflies, dragonflies, roaches, grasshoppers, the hemipteroid bugs, and various relatives all work from babyhood. They face a hostile world, however, and take on a defensive and, in carnivorous forms, an aggressive behavior, almost that of an adult in many respects. The termite society, on the other hand, has shut itself within its antproof walls where all vestiges of an aggressive behavior pitted against a hostile world have been reduced

CHILD LABOR IN A TERMITE SOCIETY
(Assuming a life of 7 instars in all castes)

	Instars of nymph 1 2 3 4 5 6	Instar of adult 7	
Queen........	Work-work-work-work.....	Rears 1st brood	15 years?
Male.........	Work-work-work-work.....	Digs nest...................	15 years?
2nd queen....	Work-work-work-work. ...	....	years?
3rd queen....	Work-work-work-work.....	....	years?
Soldier (1)....	Work-work-work-work-work	work-work-work............	2–5 years?
Workers (10).	Work-work-work-work-work	work-work-work............	2–5 years?
..	Work-work-work-work-work	work-work-work-work-work	
..	Work-work-work-work-work	work-work-work-work-work	
..	Work-work-work-work-work	work-work-work-work-work	
	Immature nymphs-work	*Immature "adults"*-work-work	
..	Work-work-work-work-work	work-work-work-work-work	
..	Work-work-work-work-work	work-work-work-work-work	
..	Work-work-work-work-work	work-work-work-work-work	
..	Work-work-work-work-work	work-work-work-work-work	
..	Work-work-work-work-work	work-work-work-work-work	

Original

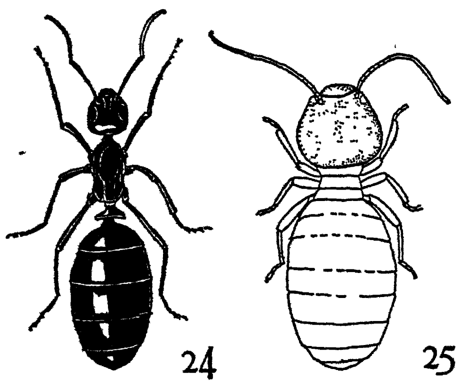
FIG. 23. CASTES OF TERMITES

CHART SHOWING THE IMMATURE WORKERS OF ALL CASTES OF RETICULITERMES AT LEFT OF VERTICAL LINE AND THE "ADULT" INSTAR OF WORKER, IMMATURE IN STRUCTURE AND BEHAVIOR, AND SOLDIER CASTES AT RIGHT OF VERTICAL LINE. TEN WORKERS AND ONE SOLDIER ARE SHOWN.

to the lowest terms. With termite behavior stricken of aggressive individualism, we are tempted to think of it in its various aspects as almost a baby behavior.

The other bit of evidence that points to a society built on the labor of immatures is that of the great difficulty found by students of termites in rearing observation colonies. Light started a hundred and lost all within a year. Only one or two investigators appear to have certainly reared individual termites of Reticulitermes stage by stage from egg to old age. The difficulty appears to be that termites are so highly social and so delicately adjusted to the enclosed, purely social environment that the investigator cannot set up any similar environment for a few individuals that he can mark, count, and watch. He has not been able with the best insectary methods to devise an artificial, environmental crowd or mob, which is the only environment to which a termite is adjusted to react. There is no other type of environment for a termite adjusted to live in a large colony of tens of thousands. In behavior termites are children of the mob.

Some data have been procured from new colonies started by a royal winged pair or by a pair of second-form reproductives. It may take a year or two to produce one soldier and half a dozen workers. The stimulating mob psychology is absent. Apparently workers from a large nest which have been born into a mob cannot be removed and stand the quiet of a small group. In the words of Professor Light, "They die of no apparent cause whatever."



FIGS. 24, 25. ANT VERSUS TERMITE
(24) MATURE WORKER OF A FORMICINE ANT, WITH FULL ADULT STRUCTURE (EXCEPT WINGLESS AND STERILE) AND ADULT BEHAVIOR (EXCEPT IN MATING AND OVIPOSITION). NOTICE THE WAIST WITH "SCALE." (25) THE SO-CALLED "MATURE" WORKER TERMITE: NO WAIST, BODY SOFT AND PALE.

We have wondered if this delicate constitution may not be correlated with immaturity. In studies of insects reared from the egg there are so many exceptions that we merely suggest this idea for consideration. But the possibility remains that we are dealing in the termites with an immature behavior, one which apparently has not acquired the partially adult versatility against even small changes in environmental conditions.

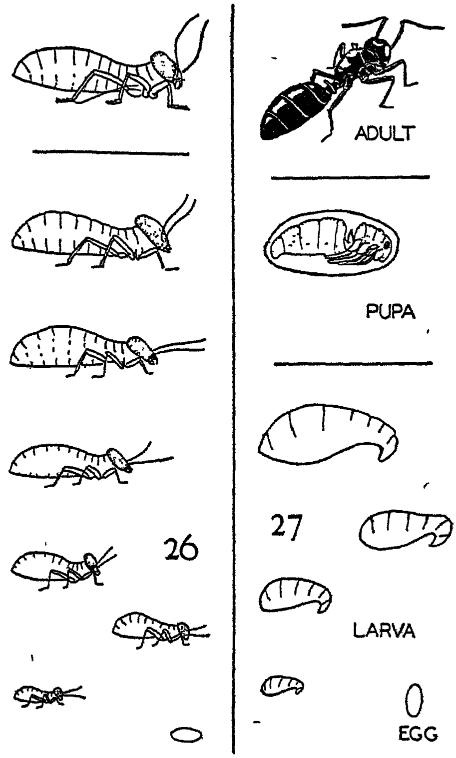
We see, then, in a termite colony a great society in which virtually all work is accomplished by immature forms. We see an immaturity that evolution has permitted to spread through the society to encompass a soldier caste, a great worker caste, and finally two reproductive castes of complemental males and queens. For emphasis in discussion we wish to point out that the termite colony is a society based on "child labor."

In passing to a comparison of termite social life with social life among the ants, probably one of the most illuminating diagrams published is one by Fuller, South African termitologist. Figures 24, 25, 26, and 27 are parts of that diagram redrawn from Hegh's copy in *Les Termites*. They compare the incomplete metamorphosis of the life of a termite, in which the nymph is self-supporting from about the second instar, with that of the ant of complete metamorphosis, where the ant can do nothing for itself until it has passed through a larval *and a pupal* state and has come out of the latter as an adult. Thus, by the nature of the type of metamorphosis a termite works through childhood (Fig. 26), whereas the ant (Fig. 27), being a mere grub in its youth, followed

by a pupal state, can do no work until it is an adult. In fact, because the worker termite never arrives at an adult form, since all stages of its active life remain nymphal, it actually has no metamorphosis even of the incomplete type. It remains childlike in form unto death and is actually ametabolic, or without metamorphosis. The winged reproductives have incomplete metamorphosis, as did their cockroach ancestors.

The other life history in Figure 27 is that of any black formicine worker ant. A mature, though wingless, worker is at the upper right. The ant has complete metamorphosis because as a youth it is a grub, which in the fourth instar spins a silken cocoon within which it rests and changes to a pupa and then into an adult. Complete metamorphosis in insects is one of the most versatile energy-saving mechanisms produced by animal evolution. The major life processes are divided into (1) growth in the larva, (2) differentiation in the prepupa (last larval stage) and pupa, and (3) reproduction in the adult. The three different physiological conditions do not conflict with each other. An adolescent ant can waste no energy in its youth by sowing wild oats. She passes into sleep as a fourth-stage baby, passes through metamorphosis while asleep, and wakes up into adulthood. One advantage shows in speed of life history. A termite spends a year or so growing up. An ant grows up in two or three weeks. The greatest body of evidence showing the advantage of complete metamorphosis appears in the development of numbers of species in the higher insects. Those orders with incomplete metamorphosis, excepting the Homoptera, more or less obligate to various plant hosts, have from a thousand to a few thousand species. On the other hand, the higher orders with complete metamorphosis have species numbers in the hundreds of thousands. As an energy-saving mechanism complete metamorphosis works. We shall see how it accumulates energy in larval fat and pours the energies which would be used up in nymphal activities over into the adult, with its fully developed sense organs, its mouth parts, and, especially, its brain; all this for the more active and more highly skilled behavior of adult life.

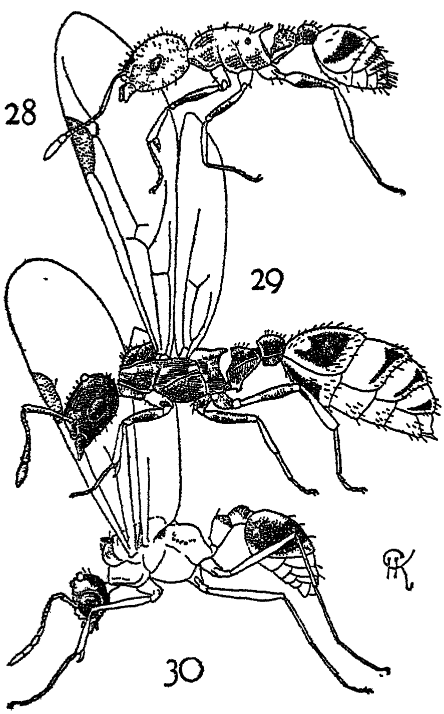
The working ant society is composed of females only. Once a year males appear for a brief period, and die after a nuptial flight of a few days, after which the colonies settle down to another year of purely female activity. Figures 28–30 show the two castes, the first reproductive, composed of the large queen and little male, and the second caste,



Rearranged from Hegh, from Fuller, South Africa

FIGS. 26, 27. FROM EGG TO ADULT

(26) EGG, SIX NYMPHAL INSTARS AND THE SEVENTH, OR SO-CALLED "ADULT," INSTAR OF THE WORKER TERMITE. THE "ADULT WORKER" IS SIMILAR IN STRUCTURE AND HABIT TO THE PRECEDING NYMPHAL STAGES. (27) COLUMN SHOWING EGG, FOUR HELPLESS LARVAE, QUIESCENT PUPAL STAGE, AND AT TOP THE ANT WORKER, A FEMALE MATURE IN STRUCTURE (EXCEPT WINGS AND REPRODUCTIVE SYSTEM) AND MATURE IN BEHAVIOR (EXCEPT STERILE).

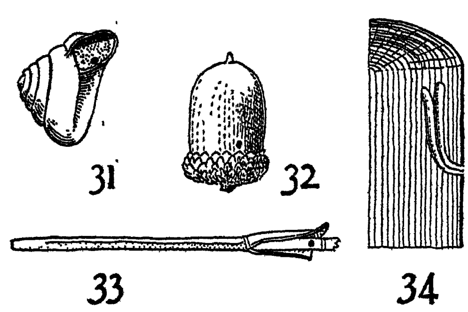


FIGS. 28–30. A MYRMECINE ANT
LEPTOTHORAX CURVISPINOSUS, A MINUTE ANT NESTING IN ACORN SHELLS, ETC. (28) WORKER. (29) QUEEN, BEFORE LOSS OF WINGS. (30) MALE.

ants as we know them, illustrated by a wingless female worker (Fig. 28). All are of the genus Leptothorax, a minute ant which builds colonies in dry plant stems, acorns, nuts, and such minute containers (Figs. 31–34). These are small colonies usually of only fifty to a hundred workers. In other ants there may be two or more castes of workers, such as large-headed soldiers with strong jaws, minute minors, and larger field-workers. Some species may build colonies up to tens of thousands of workers with a dozen or more productive queens.

When we examine the domestic economy of the ant society, we find that the larvae or immature ants, children in our present thesis, do not work beyond, in some species, spinning the silk cocoon used by the pupa. Figure 35 is a diagram of castes and their working schedules in a myrmecine society, where pupae are without a cover or silk cocoon. There is no child labor. Being legless grubs without developed eyes, antennae, and jaws, they merely lie on the floor of the home where placed by the adult female workers. They may be stacked or, as in Stenamma, related to Leptothorax, they may be laid side by side in curving rows. The ant grub cannot use immature organs and immature behavior as used by the child termite. It does not have them to use. *However*, that grub faces the external world *vicariously*. It has the use of the fully mature organs, mouth parts, senses, and, especially, mature behavior of its adult nurse ants, the ant workers. At no time does any ant *child labor* impinge on the internal nest environment or on the vicissitudes of the environment external to the society. All work within the society's walls is done by ants in the adult stage, while all work in the field where the maximum of danger exists is done by the fully developed and fully educated adult. The mature worker honeybee is known to undergo an education of two to three weeks. Little is known about ant education, but it is probably somewhat similar and would occupy the first two or three weeks of adult life.

Compare with the preceding a possible education of the termites, which pass through six or more active instars. Education must be repeated after each ecdysis, or shedding of the skeleton. Some education may be carried over through ecdysis, but



FIGS. 31–34. NO HOUSING SHORTAGE
NESTING PLACES OF SPECIES OF LEPTOTHORAX.

try shedding a skeleton between semesters. In the ant ecdyses are reduced to five and are rushed through in a few days. The forces of the total life energy are stored in the grub as fat, which is transformed later into structures and energy used in a very active adult life. In the latter there is time for two or three weeks of education. The ant newly arrived at adulthood learns at first as a timid, worker-fed callow by exploring the nest, then as a nurse caring for others within the nest, then as a timid explorer in the open near the nest, and finally as a hard-boiled fieldworker that brings home the honeydew and "bacon." And she brings them home.

Every square foot of the world's land surface in warm weather, except perhaps in extreme deserts and high latitudes, is patrolled for food by ants every day. This is a man-sized job, though it is done by lady ants. From scouting picnics to robbing the kitchen, ants are thought of as very busy, persistent, and even nervy creatures. They are in business and mean business. This is mature, adult behavior.

In comparison with the termite workers, which stay at home, eat the house, and depend for protection on ages-old immunities against microorganisms or on the walls of the house and on the defensive efforts of a few stupid soldiers against large enemies, we find that the ants defend themselves by attack. They have never lost their nerve. They travel over the most dangerous environment known, the surface of the ground. Man himself did not reach high intelligence until he came down out of the trees and faced the lions, tigers, wolves, and other dangers of the ground. These dangers speedily eliminated the feeble-minded and made man what we have seen him to have been as a Cromagnon artist and a Greek philosopher. Human populations were weeded vigorously by ground dangers. The ant has always faced the same top dangers.

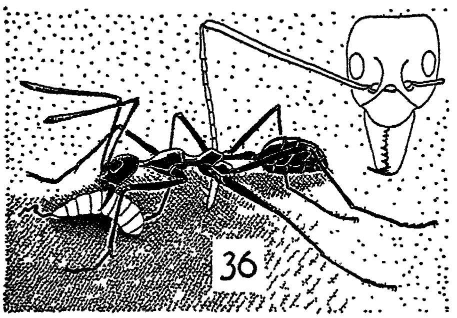
Adult Labor in a Myrmecine Ant Society
(Assuming a life of 6 instars in all castes)

	Instars 1 2 3 4	Pupa 5	Adult 6	
Queen	....	.....	Rears 1st minors..........	15 years?
Male	....	......	..1 month	
Soldier (1)	....	......	Work-work-work	Adults mature in anatomy and behavior
Workers (10)	....	......	Work-work-work	
	....	......	Work-work-work	
	....	......	Work-work-work	
	....	......	Work-work-work	
1 Soldier	....	......	Work-work-work	Adult life shortened by intense activity
to	....	......	Work-work-work	
10 Workers	....	......	Work-work-work	
	....	......	Work-work-work	
	....	......	Work-work-work	
	....	......	Work-work-work	

Original

FIG. 35. CASTES OF ANTS

CHART SHOWING THREE CASTES, REPRODUCTIVE, SOLDIER, AND WORKER, OF A MYRMECINE ANT SOCIETY. ALL WORKERS ARE ADULT, AS IS SHOWN AT THE RIGHT OF THE TWO VERTICAL LINES.



Face from Bingham; ant from Doflein

FIG. 36. A SILK-SEWING ANT

THE ORIENTAL ANT, OECOPHYLLA SMARAGDINA CARRYING A LAST-STAGE LARVA WITH A THREAD OF SILK EXTRUDED FROM THE SILK (SALIVARY) GLAND.

Only perfected behavior could have saved her with her feet on the ground.

Let us review a few of the things into which this vigorous adult behavior has evolved.

Ants are cleanly. The dead are honored with a cemetery, which also happens to be the garbage pile. They are eaten at home only under great pressure of starvation. Defecation of immature forms in the nursery is absent.

Some ants cultivate fungi for food and thus are farmers. Other ants, such as the common yard Lasius, tend herds of honey-dew-producing scales and aphids. They collect the fall eggs of these and in the spring place the young on the correct plant. Some species may even cover their herds of "ant cows" with mud sheds, which protect them from parasitic wasps and syrphid flies. Others become ant robbers and slave makers. Some species are so addicted to slavery that they cannot feed themselves. The slave ants chew the food and put it into their masters' mouths. Some ants are harvesters of grain-producing grasses and have soldier "nutcrackers" that stay at home and hull the grass seeds. Species of our common Formicas clear away young trees from the nests and thus obtain more of the sun's warmth for rearing brood. It is done by girdling the sapling and squirting formic acid in the wound. Some large Formicas build paths, and even tunnels, from nest to nest, apparently merely for greater social life. In the tropics we have the great hordes of army ants that do almost as they please —not a life pleasant to consider, but one of very vigorous adult behavior.

Perhaps the most astonishing thing done by ants is the building of silk-sewn nests by Oriental ants of the genus Oecophylla (Fig. 36). These build nests of living leaves in bushes and trees (Figs. 37–39). A group of workers, on deciding to add another leaf to the house, may have to pull it into position by a living chain as shown in Figure 37 (by Doflein?). Having pulled it into position, they hold it so by the use of jaws and tarsal claws (Fig. 38) while other workers (Fig. 39) go into the nest, select larvae ready to spin the silken larval cocoon, bring these up, and touch the larval mouth where the silk glands empty, first to the edge of one leaf then to the other. The silk hardens instantly, sewing the leaves together. This project, which is one in engineering, is usually called instinctive behavior; we can call a very high-grade adult behavior.

As a summary of our thesis that the work in a termite society is accomplished by child labor, whereas that in the ant society is almost wholly adult labor, we shall review the two bodies of evidence.

1. The termite society is built on incomplete metamorphosis, in which type of ontogeny the young from the first or second instar rustle their living. In Reticulitermes (Fig. 23) the young of all castes work, with the possible exception of those in the first instar, which may depend wholly on food given them by older workers. Workers in the final instar, which caste constitutes 90 percent of the society, retain their youthful sterility, their immature structure, and immature behavior during a life of two or more years of work. The soldiers, males, and queens become dependent in the fifth or sixth instar.

The ant society (Fig. 35) is built on com-

plete metamorphosis. Every caste passes through an inactive larval stage and a quiescent pupal stage and is active only in the adult stage. The males mate and die. With the exception of cocoon production by larvae in some groups, only adult females work. The queen usually builds her first nest and rears her first brood; after this she becomes dependent on her adult worker daughters, which constitute the whole society except for the queen (or group of queens) and reproductive brood for a brief flight season. The queen may live five to fifteen years, but the very active workers probably burn themselves out in one season or less.

2. Structurally, in the termite workers, all organs are of the nymphal or immature type. They are less well developed than if they were developed on into mature forms of the same organs.

In the ant workers, structure, with the exception of wings and reproductive organs, is developed on into the completed adult form. All workers are adults.

3. Physiologically, behavior in the termites is necessarily immature in correlation with immature structure. It is slow, weak, and limited to a few specific activities. The behaviors of hunt, attack, and largely that of defense are absent.

In ants all behavior external to the nest is mature, vigorous, and, as shown in the previous brief of activities, the richest in varied behavior known for any group of insects. (Exceptions are repletes and queens in some parasitic ants.)

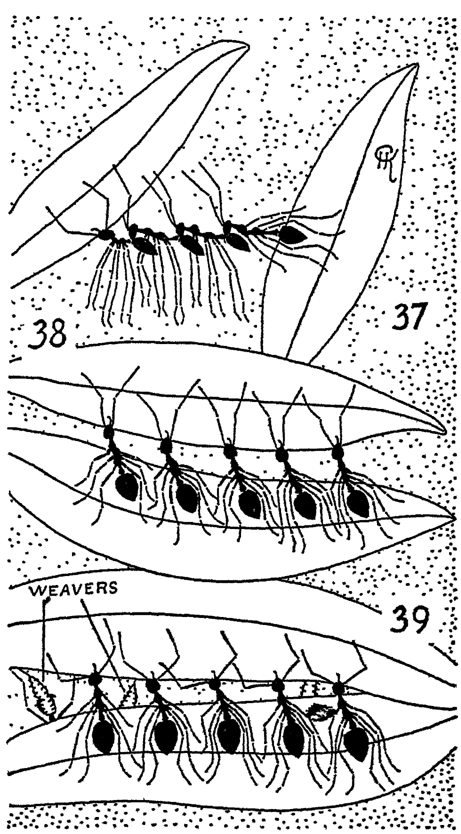
4. The slow nymphal or immature behavior of the termite is correlated with a long (two years) nymphal life and a long (two to five years) last-instar life. The total life energy of the irreversible energy-transforming mechanism is extended over two to five years because it is at a slow, weak level.

The intense adult or mature behavior of the ant is correlated with a short (two to three weeks) larval and pupal life, while the very active aggressive adult life is equally correlated with a short (one season) adult life. The high level of speed, and otherwise more intense behavior, burns up the irreversible energy-transforming mechanism. The ant pays with a short life for its greater adult activity.

5. The termite workers shut within the nest have only the one simple household psychology.

The worker ants have a similar household psychology and a second more vigorous psychology that masters the dangerous environment external to the nest.

6. Education of the termite worker caste during the two years of its nymphal activity is broken by repeated ecdyses.



Redrawn from Doflein

FIGS. 37-39. COOPERATION

(37) OECOPHYLLA WORKERS FORMING AN ANT CHAIN WHICH DRAWS TWO LEAVES TOGETHER. (38) WORKERS ADJUSTING EDGES OF LEAVES. (39) WORKERS HOLDING LEAVES IN PLACE. OTHER WEAVING-WORKERS (SEEN BETWEEN THE LEAVES) WITH SILK-FILLED LARVAE SPINNING SILK ACROSS GAP.

Education of the ant worker caste is a definite period of two or three weeks at the beginning of adult activities. It is not reduced or lost by ecdyses.

7. The problem of the male occurs in all societies. In the termite society he works as a nymph for three or four instars, then evacuates the protozoa from his intestine and, if he happens to mate with a queen or a harem of queens that succeed in reaching reproductivity in a successful nest, is dependent during a long life. The majority of males die in the mating swarm. If successful he lives long and fertilizes the queen or queens at frequent intervals.

The problem of the male in the ant society is solved by the development of a seminal receptacle in the queen where living sperm is retained for fertilization of eggs during years to come. The male dies after the one mating and ceases to be a social liability. His restless antisocial behavior and upkeep are avoided.

8. The lack of wings in the termite worker is correlated with a saving of growth energy. They are not needed within a nest.

The lack of wings in the ant worker is correlated, as in the termite worker, with a saving of growth energy and also with life on the ground external to the nest; it is correlated with the greater intellectual development that comes from life in this, the most intense and dangerous environment known, where feeble minds and concurrent inept behavior are weeded out by natural selection.

Further, the loss of wings, with life on the ground, increases the ant's ability to operate, in feeding the many hungry mouths at home, at a lower temperature than that necessary for the high-speed wing muscles. It also holds speed in the outer environment closer to the low speeds needed within the nursery. The two psychologies, that of the nursery and that used in the external environment, are less likely to conflict when the speed of the latter has been reduced to that needed in walking (or running).

9. Nymphal, or childlike structure, and labor by nymphs in the termite society have evolved into the nymphal form and the nymphal labor of the two or more years of the life of the last worker instar, which is nymphal in lacking even wing pads. With 10 percent of the colony soldiers, 90 percent are nymphs or nymphlike workers with housed-in, childlike behavior.

In the ant society the workers are adult except for sterility and wings. The helpless larvae are fed, cared for, and protected by the adult organs of the nurses and field-workers, all adults. Thus even the helpless ant larvae have contacts, though these are *vicarious*, through the adult organs and the adult behavior contacts of their nurses with the nest interior and the dangerous external environment. Immature or child labor does not occur except in the spinning of a cocoon. The adult behavior of the workers is substituted for any child labor.

10. Wasmann has pointed out that, associated with the immaturity of the worker termite, polymorphism is extensively developed in the worker castes of the highest termites, the tropical Termitidae, where as many as eight castes occur in some species. His theory was that polymorphism can evolve more easily in species that are immature in form, that immaturity of form is more mutable: that the germ plasm is subject to more accidents productive of mutations and that probably more forms of rearing by feeding, etc., can occur during long immaturity. But his philosophy too often is not clear.

We believe we have made a case for immature labor of the termite society versus adult labor of the ant society. We believe it is a point of view that can be expressed in the term "child labor," with its associated terms in human sociology, which may permit a more useful comparison with the problems raised by child labor in human society. All are animal societies evolved from that protean energy-transforming mechanism called protoplasm.

THE EFFICIENT UTILIZATION OF METALS*

By ZAY JEFFRIES

Dr. Jeffries (Sc.D., Harvard, 1918) is a Vice-president of the General Electric Company, with offices at Pittsfield, Mass. Before entering industrial research, he taught at the Case School of Applied Science. In 1939 he was elected to the National Academy of Sciences. During the war he was Vice-chairman of the War Metallurgy Committee of the National Research Council and the Academy.

THE world has consumed more metal since the beginning of this century than in all previous history, and the rate of consumption reached an all-time peak during the recent World War. The evidence at hand points to a still greater rate of consumption in the future.

Since the supply of some of the metals is limited and the more accessible and richer ores will be mined out in the foreseeable future, it is necessary that these valuable assets be utilized efficiently. Perhaps a brief statement on the nature and magnitude of the metal industry will provide a helpful approach to the subject of efficiency of utilization.

The metal industry is divided into two fields, ferrous and nonferrous. There is no good reason for the division except that pig iron constitutes around 90 percent of the new-metal production. The nonferrous field includes the metallic products derived from the elements other than iron. If the rare earths are counted, around seventy of the elements are metallic. These metallic elements are major constituents in many nonmetallic products which are not part of the nonferrous metal field. For example the lime and gypsum industries, depending on calcium, are not part of the nonferrous metal industry, but metallic calcium is. In ceramic products like brick, pottery, porcelain, and cement, much more aluminum is used than in the metallic state. The former is not part of the nonferrous metal field, but the latter is. Some nonmetallic products, however, are in a sort of "no man's land." Nonmetallic salts of lead, zinc, and tin may be made from the metals, or the ores may have a common source and may be treated by the same metallurgical processes and, hence, are usually regarded as part of the metal industry.

Rhenium, hafnium, scandium, gallium, radium, and a number of the other metallic elements, including several of the rare earths, are not used in the metallic state, or their use is so small as to be inconsequential. The metals comprising the present nonferrous industry may be divided into two main groups:

1. Metals used in substantial quantities in the pure state or serving as the bases for alloys.
2. Metals used principally as alloying constituents.

In the first group are aluminum, copper, gold, indium, lead, magnesium, mercury, molybdenum, nickel, palladium, platinum, silver, sodium, tantalum, tin, tungsten, uranium, and zinc. In the second group the following are commercially available even though some are used in small quantities: Antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, cerium, chromium, cobalt, iridium, lithium, manganese, osmium, rhodium, thorium, titanium, vanadium, and zirconium. Plutonium and other transuranic metals should now be classed as nonferrous. Both cadmium and chromium find use in the nearly pure state in the form of electroplated coatings on other metals. Certain elements like carbon,

* From a paper presented at a symposium on "The Efficient Utilization of Materials" at the Princeton University Bicentennial Conference on Engineering and Human Affairs, October 2–4, 1946.

silicon, phosphorus, and sulphur behave in some respects like metals and are very important ingredients of alloys.

Although the tonnage production of all nonferrous metals is only about 10 percent that of pig iron, the dollar value far exceeds that of iron. In some years the value of the gold output alone has been about the same as that of pig iron.

World War II so dislocated the metal industry that it is necessary to take a series of backsights to approximate normal relationships. In so doing, one finds that copper, lead, and zinc dominate the nonferrous field to about the same extent that iron dominates the whole metal industry. The production of manganese, chromium, and silicon is relatively large, but, since these are produced mostly as ferroalloys and are used largely in iron and steel manufacture, they are not ordinarily included in nonferrous figures. Normally, aluminum, tin, and nickel are produced in annual amounts greater than 100,000,000 pounds, and during the war magnesium production exceeded this figure. The annual weight production of all other nonferrous metals combined constitutes only a small fraction of 1 percent of the total.

Our industrial civilization is rich partly because we have so many metals with such varied properties and partly because the metals are available in vast quantities, the world new-metal production sometimes exceeding 100,000,000 tons in a single year. The metal industry is even larger than this because of the recovery and reworking of great quantities of scrap. The steel industry, for example, is so dependent on scrap that the output cannot be used to reflect new-metal production. But the magic of alloying, heat-treatment, and metal-fabrication processes has added immeasurably to the richness.

In addition to the use of several of the metals in a nearly pure state, there are more than 5,000 alloys in use with significantly different compositions. Considering minor differences in composition, the various methods of fabrication, and the different heat treatments, scores of thousands of sets of properties become available for the designing engineers. One might think that the engineers would be overwhelmed with so many varieties from which to choose. On the contrary, they are continually crying for new alloys with combinations of properties not now economically available or not obtainable at any price.

Looking back about a hundred years, two phases of the metal industry are clearly apparent: the quantity phase and the quality phase. The quantity phase came as a consequence of the development of the Bessemer and open-hearth steel processes. The availability of large tonnages of steel at relatively low prices created an industrial revolution. Railroads spanned continents, and millions of tons of steel were used for buildings, ships, bridges, machines, and the like. It seemed at times that the demand for ordinary steel would never be met.

The quality phase got well underway in the third decade of this century. Paradoxically, the quantities have been the greater in the quality phase, exemplified by a world production of new metal from 1891 to 1900 of 320,000,000 tons, and from 1921 to 1930 of 760,000,000 tons. The following points reflect the transition from quantity to quality:

1. From 1885 to 1920 the ratio of pig-iron to nonferrous metal production remained about constant at 20 to 1. In 1920 there was a change in slope of the pig-iron production trend line with no corresponding change for nonferrous metals. By 1935 the ratio had changed to 14 to 1.
2. Alloy steel—that is, quality steel—is increasing at a very rapid rate as compared with ordinary steel. Some aspects of this movement are:
   a) Special steels for electrical purposes.
   b) Tool steels rich in tungsten, vanadium, molybdenum, and chromium.

c) Stainless and other corrosion-resisting steels containing large amounts of chromium and nickel.

3. Vastly increased quantities of steel used in the heat-treated condition
4. The increased use of high-priced metals in combination with steel, including clad, electroplated, spray-coated, and dip-coated steels.
5. The manufacture of products such as wire and rod with dimensional tolerances hardly possible until the middle 1920's.
6. The greatly increased use of thin-walled metal parts, such as tubes, plate, and sheet to make structures of high strength or stiffness with low weight.
7. The increased use of combinations of metals with nonmetals, such as reinforced concrete, and metal inserts in rubber and other plastics.
8. The introduction of a host of nonferrous alloys with properties only dreamed of in the quantity era Among these are the cemented carbides, alnico magnets, high-temperature alloys that made the gas turbine and jet propulsion practical, and many alloys improved by precipitation heat treatment.
9. Greatly increased use of metal products designed for ease and economy of fabrication, such as deep drawing sheet, free-machining alloys, and alloys adapted to welding processes.
10. The courage on the part of engineers to use higher-priced, long-life metal parts in machine design for quality improvement.

Many other factors could be named, but these should serve to show the quality trend.

The evolution of the quality phase has been spearheaded by metallurgical science. The knowledge of alloying and heat treatment has increased by leaps and bounds during the past several decades. Powder metallurgy has made possible many products not obtainable by other means. The advent of the precipitation hardening principle alone has given rise to some hundreds of precipitation hardening alloys. Formerly it was thought that steel had some special claim on the heat-treatment art, but today alloys rich in all the principal nonferrous metals, including copper, lead, zinc, aluminum, magnesium, silver, and nickel, are available with many properties greatly enhanced by heat treatment.

Broadly speaking, the development of the quality phase in metals has constituted a program working toward more efficient utilization. One might even conclude that the problem of efficient utilization of metals has been solved. As a matter of fact, the movement is only well started, and certain danger signals should be sounded now, even though the troubles will not reach an acute stage during the next few decades.

The consumption of some of our most useful nonferrous metals cannot continue on the present trend line without soon exhausting the richer and more accessible known ore deposits. Fortunately, there is an inexhaustible supply of iron because the earth's crust contains between 4 and 5 percent. Fortunately, also, iron will remain the most important metal for an indefinite period. The cost of production may be expected to increase because the better ores will one day be mined out, but ever-new, less desirable deposits will then be utilized.

Neither will the future of aluminum and magnesium be limited by the supply of raw material. The earth's crust contains between 7 and 8 percent aluminum, and between 2 and 3 percent magnesium, and usable concentrations, including sea water for magnesium, are available in many parts of the world. The long-term outlook is that aluminum and magnesium will assume a position second only to iron in both tonnage and value.

The nonferrous metals expected to be in short supply in the future include copper, zinc, lead, tin, nickel, tungsten, molybdenum, cadmium, bismuth, gold, silver, mercury, and tantalum. It has been estimated that the earth's crust contains only about 0.01 percent copper, 0.004 percent zinc, and 0.002 percent lead. As the richer deposits of all these metals are mined, the use of lower-grade ores will be reflected in higher prices. Higher prices, relatively, will tend to conserve these valuable metals for the uses for which each is best adapted,

which is the essence of efficiency of utilization.

These scarcer metals must be conserved by one means or another. It is even possible that man will exhibit sufficient wisdom in long-term planning to begin this conservation in the not-distant future. The quality era discussed earlier, insofar as it utilizes more of these scarce metals, works against this conservation. The use of more iron, aluminum, and magnesium favors it. In general, substitution of nonmetallics for metals favors the conservation.

Another broad line of attack is also called for. The recent war proved that, while certain of these metals are well-nigh indispensable for specific uses, there are wide overlapping areas in which substitutions can be made with only moderate impairment. Therefore, the increased production of almost any metal will relieve the strain on the scarcer metals. The increased use of iron, aluminum, and magnesium should be stimulated and will be helpful, but it is not enough. A greater future supply of some of the more abundant but less used metals and near-metals would provide additional relief. For example, manganese is sufficiently plentiful to support a large manganese-base alloy industry. This development is now barely started. Certain other elements, like silicon and titanium, can be produced in unlimited quantities if metallurgical science can tame them and adapt them to man's needs. Chromium and zirconium are relatively plentiful, and both need more future attention. Metals like calcium and sodium, available in unlimited quantities, also offer challenges to the metallurgists.

If we visualize such a campaign against the background of metallurgical history, the outlook is not too discouraging. In the first place, there will be a continuing supply of all the metals, the scarcer ones included. We may expect new ore finds of importance, and then there are, in most cases, large deposits of low grade which can be worked at a price. Improvement in mining, milling, and smelting can be confidently counted on to make the working of lower-grade deposits economical. So, the time allowed for making the developments necessary for greater use of some of the wilder but more abundant metals is long, and the advance in metallurgical science is rapid. We can face the future, therefore, with the faith that metals, if properly used, will provide a firm foundation for a much higher world-wide standard of living than anything experienced in the past. Let us hope that world politics, world statesmanship, and world sociology can keep pace with science and technology.

Having arrived at this somewhat comforting conclusion, along come transmutation and nuclear fission. Transmutation, with the advent of many isotopes, would have influenced the metal industry in time. It would have been, and is, another quality factor. It not only *adds* to the number of metals—it multiplies. But nuclear fission and the achievement of the nuclear chain reaction may prove to be a metallurgical, as well as a military, atomic bomb. At least, most of the world is now engaged in a study of how best to utilize uranium.

Perhaps we can agree that the most efficient utilization of uranium will be to end war. Here is a problem that must be tackled by all peoples, but the contribution toward its solution by metallurgists may be of great importance. It is probable that one way to avoid war is to develop healthy peacetime applications of nucleonics. Many of the problems needing solution to achieve this objective are metallurgical. Although the ultimate consequences can be but dimly perceived, nucleonics is certain to greatly enrich metallurgical science and technology, and it will constitute a seven-league-boot stride in the era of quality metallurgy.

NEGRO-WHITE DIFFERENCES IN MENTAL ABILITY IN THE UNITED STATES

By HENRY E. GARRETT

Dr. Garrett, a native of Virginia, received the Ph.D. from Columbia University, where he is now Professor of Psychology and executive officer of the department. During World War II he served as a member of the Committee on the Selection of Military Personnel, Advisory to the Adjutant General's Office. His special fields are learning and mental organization.

THE question of the existence of Negro-white differences in mental ability within the United States has of late been sadly confused with social and political issues of racial superiority, discrimination, and the like. As a result of this confusion, many writers seem to take the position that racial differences ought not to be found, or if found should immediately be explained away as somehow reprehensible and socially undesirable. With this attitude the present writer is in sharp disagreement. While he is heartily in favor of every genuine effort to aid the Negro in improving his status as an American citizen, he does not believe it is at all necessary to "prove" the nonexistence of race differences in order to justify a fair policy toward the Negro. It cannot be said too often that the honest psychologist, like any other true scientist, has no racial bias; he does not *care* which race (if any) is the more intelligent or whether all races are potentially equal in mental ability. But he *is* interested in discovering whether differences in mental ability exist, and in making inferences concerning the origin of such differences. And this would seem to be an entirely legitimate enterprise.

A study of Negro-white differences in the United States offers certain advantages—as well as disadvantages—to the student of racial psychology. A decided advantage is the fact that Negroes and whites have lived side by side in our country for more than three hundred years. The American Negro's native language is English, and he has been exposed to the same manners, customs, and environmental influences (schools, churches, movies, etc.) as the American white. On the other hand, the American Negro is generally below the white in social and economic status, and his opportunities for other than menial work are limited. The educated Negro, for instance, is restricted in his business and social contacts largely to members of his own race. While this inequality in social status makes it difficult to obtain a fair comparison of American Negroes and American whites, this can be done if proper precautions are taken. Inferences drawn from many comparisons, however, must of necessity be tentative.

Other important considerations arise in a study of Negro-white differences in mental ability within our country. The admixture of Negro and white stocks has gone on steadily over the years so that the present American Negro is rarely of pure African ancestry. Comparisons of Negroes and whites within the United States can hardly reveal *true* race differences, therefore, and are really comparisons of white and Negroid (more or less Negro) groups. Suppose, for example, that the evidence shows Negro-white mixtures to be more intelligent than pure Negroes. If differences in mental ability are found in favor of whites, then, one may infer that true racial differences would be greater if African Negroes and white Europeans were studied under comparable conditions.

How does the American Negro compare with the American white in measured ability? What are the *facts* apart from questions of segregation, considerations of social be-

havior and customs, "racist theories," and the like? Perhaps these questions can best be approached stepwise: that is, by comparing the performance in mental tasks of American Negro and American white from childhood up through adulthood.

WE MAY begin with McGraw's study in 1931 of the comparative abilities shown by 68 white and 60 Negro babies, two to eleven months old, all living in a Southern community. This study is valuable in spite of the small samples because social influences are minimal if not completely absent at these early age levels. Each baby was given a series of mental tests constructed for use during the first two years of life. The tasks involved activities designed to measure coordination and control, manipulative skill and development, memory and imitation, and elementary "reasoning" as exhibited in the solution of simple problems. For each child a "developmental quotient" was calculated to show the baby's mental development as compared with infants of his own age level. If the baby is as alert as the average of his month level, his D.Q. (developmental quotient) is 100; and this is the base from which to figure. The average D.Q. of the 68 white babies was 105, slightly better than expectation; of the 60 Negro babies, 92—eight points below expectation. The groups were about equally variable around their respective means. The white babies' D.Q.'s were better than those of the Negro at each month level from two to eleven, their superiority ranging from 2 to 25 points, and averaging 13 points. In percentage of total number of test situations done correctly, the white babies' superiority over the Negro babies averaged 12 percent. Just 28 percent of the Negro children exceeded the average D.Q. of the white babies.

These differences cannot be explained as due entirely to the better nutrition of the white babies or the better education of their parents. To be sure, the white babies were slightly taller and somewhat heavier than the Negro children. But a comparison of each group with the standard height-weight measurements given for the United States as a whole shows the Negro children to be as typical (close to the norms) of their age levels as were the white children. The educational level of the white parents was somewhat higher than that of the Negro parents, but the difference was not great. The average Negro parent reported six grades of schooling, and many reported college and normal school attendance. The average white parent reported high-school training, but many had attended only the elementary school. Three features of this study are noteworthy. First, environmental influences were minimized if not eliminated, and differences still appeared; second, the white babies became increasingly better as the upper and more difficult levels of the scale were reached; and third, considerable overlap in achievement was found—that is, about one-fourth of the Negro children performed better than the typical white baby.

The scores of Negro school children on standard intelligence tests are usually reported in terms of I.Q., for which the norm for white children is 100. A very large number of investigations of the comparative abilities of Negro and white children, both in the South and in the North, have been carried out. These studies differ markedly in the size and adequacy of the samples measured and in the validity of the mental tests employed. But they are consistent in giving the Southern Negro child an average I.Q. rating of about 80 and the Northern Negro child a slightly higher average, 85–90. Not all this retardation appears to be a matter of restrictive environment, though some of it undoubtedly is. In one study in which white and Negro children were really equated for social and economic status, the difference was much reduced, but it may be noted that even the white children of inferior and very inferior social status were 7–10

I.Q. points ahead of the Negro children. This same result has been found for a group of nearly 1,000 Negro and white children tested in a rural section of Virginia. Even the Negro children in a relatively favorable environment (Los Angeles, for example) do not average more than 105 I.Q.

Until test results from World War II are available, the best data on the comparative achievement of American Negro and white adults are provided by the intelligence tests given to nearly 1,750,000 soldiers in 1917–18. Two mental examinations were used in World War I, known, respectively, as Army Alpha and Army Beta. Alpha was a verbal, or language, test, requiring the ability to read and write. Beta was a nonlanguage test. The subject did not have to read or write, but simply indicated his answers by marking with a pencil. White soldiers scored higher on both Alpha and Beta than Northern Negro soldiers, who, in turn, scored higher than Southern Negro soldiers, as shown in Table 1.

TABLE 1

	Alpha Median	Beta Median
White soldiers.	58.9	43.4
Northern Negro soldiers.	38.6	32.5
Southern Negro soldiers	12.4	19.8

It has often been asserted by uncritical writers that the Negro performed relatively much better on Beta than on Alpha, and this is interpreted to mean that the lower score of the Negro on Alpha is a reflection of inadequate schooling rather than a function of poorer native ability. This conclusion does not follow from the data. Alpha and Beta were scored in different units, and a 20-point difference on Alpha cannot be compared directly with a 10-point difference on Beta. If the proportions of Northern Negro soldiers who scored better than the average white soldier in Alpha and Beta are computed, it is found that 29 percent of the Northern Negro soldiers exceeded the average white in Alpha, and 27 percent exceeded the average white in Beta. The Negro soldier lagged to about the same degree, therefore, whether the test was for literates or illiterates. When Negro and white soldiers were compared on a country-wide basis in terms of the "combined scale" (a test made up of prorated scores on Alpha, Beta, and individual examinations), about one Negro soldier in seven or eight did as well as the average white soldier.

As shown in Table 2, Northern Negro soldiers from New York, Ohio, Illinois, and Pennsylvania scored somewhat higher in the Alpha examination than Southern white soldiers from Georgia, Arkansas, Kentucky, and Mississippi. This finding has often been cited as evidence for the view that Negro-white differences in mental test performance are fundamentally environmental and are not genetic or native. Again it must be said that this conclusion (though it may be partly correct) does not follow from the data. In the first place, Table 2 represents extreme and rather small selections. When Negroes in the four Northern states are compared with whites in these same states, the overlap is 28 percent, almost exactly what it is in the country as a whole. One might argue, therefore, that given better schooling the Negro does indeed improve

TABLE 2

MEDIAN SCORES OF SOUTHERN WHITES AND NORTHERN NEGROES IN CERTAIN STATES (Alpha Only)

Whites			Negroes		
State	N	Medians	State	N	Medians
Georgia.	702	41.6	New York. . . .	850	44.5
Arkansas. . . .	618	41.0	Ohio.	152	48.8
Kentucky. . . .	832	41.0	Illinois.	578	46.9
Mississippi.	665	40.8	Pennsylvania. . .	498	41.5

his Alpha score—but not his position relative to the white. Again, one might argue in favor of race differences on the ground that white Southerners performed as well as highly selected Northern Negroes in spite of educational handicaps which, unfortunately, affect whites as well as Negroes.

The better showing of the Northern Negro as compared with the Southern Negro has often been explained by the "selective migration" of the more intelligent Negroes to the North. Selective migration is disputed by writers who favor the environmental explanation of Negro-white test differences. These insist that as often as not it is the shiftless and ne'er-do-well Negro (of presumably low intelligence) who leaves the South for the North. Several studies made in 1935 by Professor Otto Klineberg bear directly upon this problem of selective migration. It is worth while examining Professor Klineberg's evidence with some care, as many writers think it disproves the selective migration hypothesis and favors the environmental explanation. As recently as 1946, for example, one psychologist wrote that the argument for selective migration has been "largely invalidated" by Klineberg's work.

In his first study, Klineberg compared the school grades of 562 Southern Negro children, whose parents had recently come North, with the grades of their schoolmates still in the South. All school grades were expressed in a simple scale in which 50 represents average performance. In two of the three Southern cities (Nashville and Charleston) the migrating children were somewhat better than the nonmigrating, their averages being 54 and 56; in the third city (Birmingham) the migrating Negro children averaged 45—below the nonmigrants. For the entire group of 562 migrating children, the average was 49, which on the face of it offers no evidence for selective migration. But unfortunately this result offers no evidence *against* selective migration, either. Dr. Leta S. Hollingworth, an eminent child psychologist, has pointed out that a difference of 20–25 points in I.Q. is usually necessary before teachers recognize clearly the gap in mental ability between two children and reflect this difference in their school marks. The average I.Q. of the Southern Negro child, it will be recalled, is about 80. The migrating Southern Negro children would have had to possess I.Q.'s of 100–105 on the average, therefore—significantly higher than that of the average Southern Negro child—for Klineberg's method to have found them superior in their school marks to their nonmigrating classmates. It may be added, furthermore, that the migrating children were taken North by their parents, and that the relation of intelligence in parents and offspring is not perfect. Even if the migrating children were no more intelligent than the nonmigrants, therefore, we cannot say that their parents, who initiated the migration, were no more intelligent than their neighbors who stayed behind.

In a second study, Klineberg compared the scores on several standard intelligence tests made by twelve-year-old Negro children whose parents had lived from one to twelve years in New York City. Two facts emerged from this study: (1) The average scores made by the Negro children were better the longer they had lived in New York City. (2) The twelve-year-old Negro children, both the migrants and those born in New York City, were from six months to one and one-half years in "mental age" behind white children of the same age level. Environment did indeed raise the scores of these Negro children, but even under relatively favorable conditions it did not bring them up to the white standards. This same result, it will be remembered, was found when the Alpha scores of Negro soldiers in Northern states were compared with the Alpha scores of white soldiers in the same states.

The fact that bright and very bright

American Negro children can be found in American schools is often cited as another argument that environmental and not native factors account for Negro-white differences in performance on mental tests. In one well-known study, a systematic search was conducted for superior Negro children in Grades III–VIII of seven Chicago public schools in which approximately 8,000 Negro children were enrolled. Altogether, 103 children were located with I.Q.'s of 120 or above on the Stanford-Binet Intelligence Test. Of these superior children, about one-fifth reported no white ancestry, the remainder being of mixed Negro and white ancestry in varying degree. The parents of these children were above average in education and in social and economic status.

It is difficult to see why this study should be regarded as so strongly favoring the environmental hypothesis. No responsible person to my knowledge has ever claimed that *all* Negroes are less intelligent than *all* whites. As has been shown above, *at least* 25 percent of American Negroes, whether children or adults, achieve scores higher than those of the average American white, and this overlap in score allows for many bright and very bright Negroes. At the same time, it should be pointed out that in a sample of 8,000 white school children at least 800 can be expected to possess I.Q.'s of 120 or higher. This means that only one-eighth as many bright Negro as bright white children will probably be found in the general school population even under exceptionally favorable conditions.

THE facts brought out in this survey may be briefly summarized as follows:

On tests of mental ability, American Negroes on the average rank consistently lower than American whites. The regularity of this result from babyhood to adulthood makes it extremely unlikely, in the present writer's opinion, that environmental opportunities can possibly explain *all* the differences found.

Approximately 25 percent of Negroes do better than the average white, and many make very high scores. Under favorable conditions, about one-eighth as many bright Negroes as bright white children can be expected in our schools.

Neither the selective-migration hypothesis nor the environmental theory is a complete explanation of the differences found between American Negroes and whites, or between Northern and Southern Negroes.

The point may be stressed again that the differences between American Negroes and American whites are not true racial differences. What differences would be found between African Negroes and European whites is not known, but it is a fair assumption that they would be greater than the differences found between whites and Negroids in the United States.

A LETTER

By Paul D. Harwood

Dear Marjorie:
In Houston all this fall
I've watched the slow and colorless dropping of the leaves.
As their time nears, they turn a duller green,
And next one sees them all upon the ground—
A motley heap of yellow mixed with brown.

I had not thought to miss the autumn's riot so;
The panoramic never held me with its awful sweep,
Instead I've looked for beauty in some little thing—
Such as the caddice case, the lace-bug's wing.

Our trees are nearly bare except live oaks
Whose dark, thick leaves outlast the sun's decline.
And yet, today, I came upon a myrtle bush
Whose every leaf had turned a deep, bronze red.
Quite suddenly I was alone amid a crowd,
And I've returned to worship when my time allowed.

Among the yellowed host of maple trees
Above Cayuga Lake, we've known white oaks
Whose leaves have turned this bronzy red
Where they were mixed upon the long, steep hill
With other oaks whose leaves were redder still.

Because we shared all that last fall,
Nostalgia holds my heart tonight.

Yours,
Paul

THE STORY OF ETHYLENE

By ERSTON V. MILLER

Dr. Miller (Ph.D., Michigan State, 1926) was, until recently, a plant physiologist with the Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, U.S D A., at Orlando, Fla He has resigned in order to accept a professorship in the Department of Biological Sciences at the University of Pittsburgh Formerly in academic work, he spent three years as an instructor in science at the Shanghai (China) American School and one year at Michigan State College before entering the Bureau of Plant Industry.

ETHYLENE is a colorless hydrocarbon gas with a sweetish odor, having the formula C_2H_4. It belongs to the unsaturated group of hydrocarbons called "olefins" and, because of its unsaturation, it combines readily with bromine and chlorine. The organic chemist finds this hydrocarbon gas useful as a starting point in the manufacture of a great variety of substances of commercial value. Tetraethyl lead, which is used by the petroleum industry in the manufacture of "ethyl", or antiknock, gasoline, is derived from ethylene. In medicine ethylene has found use as an anesthetic and in some respects is believed to be superior to ether. But we are concerned in this article with the role of ethylene in the field of plant physiology.

To begin at the beginning we must turn back the pages of history to the time when the Chinese ripened hard pears by placing them in closed rooms with burning incense. They ripened the pears in this manner "because their fathers before them did so." Little did the Chinese people realize that in the smoke from the incense was this gas called ethylene, a compound capable of influencing physiological processes of fruits, vegetables, flowers, flower bulbs, roots, tubers, and germinating seeds, and so potent a substance as to be able to make its presence known, in some instances, when present to the extent of only one part in sixty million parts of air.

But the Chinese are not the only people who have utilized ethylene without knowing it. At the beginning of the present century it was customary to ship oranges from Florida to Northern markets in railroad cars heated with kerosene stoves to prevent freezing. At the time it was noted that the green-colored fruits in the car assumed the characteristic orange color during transit, but this was considered merely a ripening process caused by the heat generated by the stoves.

In 1912 Sievers and True, working with lemons, showed that the active agent bringing about the color change was to be found in the products of incomplete combustion of the kerosene stove and that heat was of secondary importance. Furthermore, the fruit could be "degreened" by the exhaust gases of a gasoline motor. However, the actual identity of the coloring agent was still unknown. In 1923 Denny suspected that this strange gas was an unsaturated hydrocarbon because he found that the fumes of the kerosene stove were rendered ineffective as a coloring agent if they were first filtered through bromine water. Ethylene was a well-known unsaturated gas at that time, although its properties as a coloring agent were unsuspected. But when Denny substituted small quantities of pure ethylene for the kerosene fumes in the coloring of citrus fruits, he found the ethylene gas much more effective. Thus began the practice of degreening citrus fruits with ethylene on a commercial scale.

For years now the ethylene treatment has been given to early oranges, such as Parson Brown, Washington Navel, and Sat-

suma, as well as any other variety of orange or grapefruit that fails to color properly on the tree because of having grown in the shade of dense foliage. The Valencia (late) orange usually develops a good yellow color in the winter while still immature and then turns green at the stem end as it matures in the spring. These fruits are given the ethylene treatment to remove the green pigment (chlorophyll) from the rind. Lemons are picked according to size and not color, and the green ones are colored by storing at 50°–55°F. for 30–60 days before marketing, unless the demand is brisk, when they are subjected to forced curing, or coloring, with ethylene.

After the citrus industry, the banana industry was perhaps the next to make a commercial practice of using ethylene. Because of their softness, ripe bananas cannot be shipped from the tropics to the markets. For years, therefore, it had been customary to ship mature green bananas and ripen them at their destination with kerosene stoves. Following the discovery of the effect of ethylene on physiological processes of fruits, this gas has been used to hasten the ripening of bananas. One of the main advantages in using ethylene rather than kerosene stoves for this purpose is that a much lower temperature may be employed, thus reducing the amount of decay.

After Denny reported that ethylene was more effective than the fumes of kerosene stoves in coloring citrus fruits, physiologists began experimenting with the coloring and ripening of other fruits and vegetables. In 1925 R. B. Harvey reported on a new method for blanching celery. Harvey recalled that in 1908 certain greenhouse operators in Chicago had reported that rosebushes were being defoliated and that leaves of other plants were becoming etiolated, or blanched. Crocker and Knight had been called in to investigate and found that gas was leaking from the city mains and that the ethylene in the gas was responsible for the peculiar physiological effects on the greenhouse plants. It was this report that suggested to Harvey that ethylene might be used for blanching celery. At the time it was customary to blanch celery in the field by placing boards, paper, or soil around the plants and leaving them so enclosed until the green pigment in their stalks disappeared. This process required 8–10 days. When ethylene was used in the blanching process, the time could be reduced one-half. In some sections of the country the ethylene method for blanching celery was adopted by the industry but was abandoned later when it was learned that enlargement of celery "hearts" occurred only during field blanching.

During the ensuing years ethylene ripening was recommended for tomatoes, pineapples, cantaloupes, dates, jujubes, persimmons, pears, mangoes, pomegranates, peppers, avocados, honeydew melons, apples, plums, papayas, chayotes, cherimoyas, plantains, endive, chicory, and rhubarb.

It was found during these investigations that ethylene merely acted as a trigger in setting off the enzymatic processes which bring about coloring or ripening. Perhaps it would not be out of place at this point to discuss some of these processes, at the same time describing some of the differences between the changes taking place in fruits that are ripened by ethylene and in those that are only colored in the process. It has been emphasized by many students of this subject that the ethylene treatment of citrus fruits consists of a "degreening" and not a ripening process. The green pigments are destroyed in the process, revealing the yellow pigments, which were present all the time but which were masked by the green pigments. Analyses have shown that sugar is not increased, that acids are not decreased, and that vitamin C is not affected by the ethylene gas. It is obvious, therefore, that ethylene is only a coloring agent insofar as citrus fruits are concerned.

When oranges ripen during warm weather, like the early varieties in Florida, and reportedly all varieties in tropical countries, they may become edible before they lose all their green color. Residents of the tropics are accustomed to seeing green oranges, and they accept them. On the other hand, since most of the varieties in the United States ripen during cold weather and are fully colored, the consumer is prejudiced against a green-colored orange. This has given rise to the practice of coloring or degreening early oranges and certain other citrus fruits with ethylene.

Most of the fruits and vegetables mentioned in this article can be actually ripened with the use of ethylene gas. Fruits like the apple, pear, and banana are usually picked in the "mature green" stage and are permitted to ripen after removal from the tree. Ripening in this case consists of an increase in sugar content, a loss of acidity, in some instances a loss of astringency, and a general improvement in texture and flavor. Softening is the result of conversion of protopectin into pectin. The increase in sugar is made possible by the presence of a "carbohydrate reserve" in the mature green fruits, which is hydrolyzed into sugar during ripening. These processes proceed whether the fruits are left on the tree or harvested, although there are often more advantages in harvesting in the mature green stage and permitting the fruits to ripen at an optimum temperature in storage than in harvesting them ripe. The ripening processes can be hastened by using ethylene.

Citrus fruits do not have a carbohydrate reserve and do not undergo a softening during ripening, so that they must be ripe when harvested if they are ever to be ripe at all. Before oranges can be colored with ethylene they must first meet certain standards of maturity which have been established by regulating agencies in the state in which the fruit is being produced.

Specifically, therefore, the fruits that may be picked in the mature green stage and ripened after harvest are the ones that can be ripened with ethylene. In certain fruits, like the pineapple, that do not possess a carbohydrate reserve, increased sweetness has been shown to be the result of the inversion of sucrose. Reduction of acidity also accounts for improvement in flavor during ripening of many fruits. In one type of fruit, ripening is accompanied by a reduction in astringency. The banana, date, and persimmon belong to this group. Astringency in the green fruits is caused by the presence of soluble tannins. It has been shown that during ripening, with or without ethylene, the tannins are not destroyed but are rendered insoluble by being combined with colloidal carbohydrates.

Tomatoes are both colored and ripened by ethylene, and coloring in this instance is more than just a degreening because the orange-red pigments actually increase in quantity during the process. The color of a ripe tomato is due largely to lycopene, an isomer of carotene, and it has been observed that lycopene continues to develop in fruits after removal from the vine. If oranges are held an extra day in ethylene, the color of the rind deepens, although the total quantity of carotenoid pigments does not increase. There apparently occurs a shifting of carotene or some other pigment to lycopene. Occasionally a grower will subject fully colored oranges to ethylene in order to enhance the color a little. However, unnecessarily prolonging the ethylene treatment of oranges is to be discouraged because such a practice increases the fruit's susceptibility to decay.

One general effect of ethylene on all fruits and vegetables, whether they are colored or ripened, is to increase the rate of respiration. It has been shown, for example, that the ethylene treatment of lemons may increase the respiration rate 100–250 percent. The astonishing feature about this gas is the low concentrations in which it is effective. Ex-

periments have demonstrated that the respiration rate of lemons may be increased by ethylene in concentration of 1 part to 100 parts of air, 1 to 10,000, 1 to 100,000, or even 1 to 1,000,000, although the best coloring was obtained in these experiments in the intermediate concentrations (1 part of ethylene to 10,000 or 100,000 parts of air). When ethylene is used as an anesthetic for humans, four parts of ethylene are required to one part of air.)

An attempt has been made to show that ethylene stimulates the natural processes in fruits and vegetables and serves to bring about, in a short time, changes that would occur in nature only after a much longer period. The claims that certain ethylene-treated fruits are sweeter than the untreated ones were doubtless based on analyses made simultaneously on treated and untreated fruits. The ethylene-treated fruits, naturally being riper than the controls, would be sweeter. In more recent years analyses made on control lots, after they had attained the same degree of ripeness as that of the ethylene-treated lots, showed the same chemical composition. Thornton, in his paper published in *Food Industries* (12 [7]: 48–50; [8]: 51–52, 1940), entitled "The Facts about Artificially Ripened Fruit," emphasizes this point by citing references from all over the world that cover a large number of fruits and vegetables.

THERE are three distinct parts to this story. First, it will be recalled, oranges were colored with kerosene fumes, and pears were ripened with incense smoke, but the active constituent of these fumes was not known. Second, it was learned that ethylene was an effectual coloring and ripening agent. The third phase began with the discovery that a physiologically active gas was being evolved by ripening fruits in storage.

In 1910 the annual report of the Jamaica Department of Agriculture contained a statement by Cousins that bananas ripened faster when stored in the same rooms with oranges. Recommendations against mixed storage of fruits were made and apparently the matter was dropped there. This brief report on so vital a matter was either forgotten or overlooked for a number of years, and it was not until about thirty years later that this fruit-ripening gas evolved by oranges was identified as ethylene.

Meanwhile the United Fruit Company was having difficulty with shipments of bananas from the tropics. It was reported that the more mature bananas, though green when loaded aboard ship, would ripen during the trip from the tropics and affect normal green fruit adjacent to them, so that they would be too tender to be handled or distributed through trade channels after arrival at port. This problem was eventually solved by use of forced ventilation and refrigeration. Since it was found that the number of "ship ripes" varied with the amount of carbon dioxide produced by the respiration of the bananas, it was incorrectly concluded that carbon dioxide was the gas that was responsible for this artificial ripening. In 1923 Ridley, of the United Fruit Company, demonstrated by carefully controlled experiments that something produced by ripening bananas would accelerate the ripening of green fruits, and that this substance was not any of the then known by-products of metabolism of the banana. This unknown substance was called "X-gas."

In 1930 Chace and Sorber announced that a by-product of ripening pears would accelerate the softening of green pears. In 1932 Elmer reported that when apples and potatoes were stored together, the sprouting of the potatoes was inhibited. Interest in gaseous emanations from ripening fruits was now becoming widespread.

It was difficult to identify ethylene in these gaseous emanations because the gas is usually present in such very minute quantities. Identifying a substance that may be

physiologically active in concentration of two parts per million offers a challenge to the analytical chemist. It is therefore fortunate that biological methods of detection of ethylene were first employed. The method was discovered accidentally. In 1933, Botjes in Holland, and Huelin in Australia, each reported that the vapors of stored apples would produce epinasty in certain potted plants such as tomato or potato. In an epinastic plant the cells on the upper surface of the branches or leafstalks grow faster than those on the underside, with the result that the branches turn down and grow tightly against the stalk. At first glance the plants appear to have wilted, but closer inspection reveals no shriveling of the leaves. Also, when the leaves are pulled up into normal position and then released, they snap back into the depressed position.

The belief that the active constituent of the apple vapors was ethylene was based on the reports of E. M. Harvey in 1913 and of Doubt in 1917 that, when plants like the tomato were exposed to traces of ethylene, an epinastic curvature of the petioles would develop in the test plants.

During the next three or four years a number of attempts were made to identify this unknown gas. Kidd and West (1933) reported experiments that proved that the physiologically active substance in apple vapors was a hydrocarbon; and the work of Smith and Gane, during the same year, indicated that the substance might be an olefin or some complex hydrocarbon. The field of search had been narrowed in 1932 when Crocker, Zimmerman, and Hitchcock tested thirty-eight gases for their ability to produce epinasty in plants and obtained positive results with only five. These were ethylene, propylene, butylene, acetylene, and carbon monoxide. Although these tests had narrowed the search to five gases and had pointed to an unsaturated hydrocarbon. or olefin, they also served to show that the biological test (epinasty) was not specific. Following this, considerable attention was given to identifying the active gas by the process of elimination. In 1936 Elmer, analyzing the volatile products of apples that are absorbed in fuming sulfuric acid, concluded that the hydrocarbon was ethylene rather than one of its homologues. Hansen and Hartman in 1935, and Denny in 1938, eliminated the possibility of butylene and propylene by filtering the gaseous emanations through 87 percent sulfuric acid, removing any acetylene that might be present by absorbing the gas in a solution of mercuric nitrate and then liberating pure ethylene by adding hydrochloric acid. As early as 1934, however, Gane had rather conclusively proved that apples evolve ethylene. The method consisted of absorbing the gaseous emanations in bromine and converting the ethylene dibromide thus formed into crystalline diphenyl ethylene diamine. In these experiments Gane led a stream of air over sixty pounds of apples and then through bromine at −65° F. for one month. At the end of this period he had collected only 0.85 grams of an oily substance. He concluded that "the amount of ethylene produced is very small, perhaps of the order of one cubic centimeter during the whole life of the fruit."

It will be noted that during these years of search for the identity of the unknown gas present in the volatile emanations of fruits, the investigations were being conducted with such fruits as apples, pears, and bananas. Except for an isolated and almost forgotten report from Jamaica, citrus fruits were not mentioned. The subject of oranges and ethylene in this connection arose only after public attention had been focused upon coloring processes employed by the citrus industry. "The color-added" process, a method of dyeing the orange rinds to enhance the color, was claimed by certain groups to be an adulteration of a food product and was often confused with the ethylene method of coloring. Moreover, when

coloring of any kind was mentioned, ethylene usually entered into the discussion, and research workers were often asked if ethylene degreening of citrus fruits were not an artificial process. This question was put to the plant physiologists, and investigations were begun on the volatile substances evolved by citrus fruits in storage. E. M. Harvey, who had been a pioneer in studying the physiological effects of ethylene on growing plants, had observed that potato plants showed abnormal growth when placed in rooms where lemons were stored. He suggested to several of his co-workers that this phenomenon indicated the presence of some such substance as ethylene, and that there was a probability that this gas was being evolved by decay-producing fungi in the storage rooms.

In 1940 it was independently reported by Biale in California and by Miller, Winston, and Fisher in Florida that oranges actually evolve ethylene gas, that decaying fruits produce the gas more abundantly than normal fruits, and that *Penicillium digitatum*, a decay-producing organism, may produce significant amounts of this gas.

The discovery that ethylene is evolved by ripening oranges was of considerable significance to the citrus industry because it meant that the ethylene treatment could no longer be considered artificial coloring; that is to say, the method for degreening of oranges merely involves the use of larger quantities of a gas that is already being evolved by fruits and vegetables.

When the subject is considered as a whole, it becomes evident that both good and bad effects are produced by ethylene emanations. Reference has been made to the losses of banana shippers when bananas were prematurely ripened and made too soft to handle. Effects on apples also may be deleterious. It had been realized as early as 1917 that volatile substances from apples in storage were responsible for the development of scald in these fruits. Qualitative analyses of apples at the time revealed a number of substances, like alcohols, aldehydes, and esters, that are responsible for giving the apple its flavor, but ethylene was not suspected and not detected. Knowing that volatiles were responsible for scald was a step forward, and in a few years still more progress was made when it was discovered that oiled paper wraps on apples would absorb the volatile substances and reduce scald. It was not long after this that oiled wraps and shredded oiled paper were used in every apple country of the world. This practice likewise created a new type of business for paper manufacturers.

The role of ethylene in the production of apple scald was not suspected until 1942, when it was observed at Cornell University that the quantity of volatile material arising from McIntosh apples harvested in 1941 had been much higher than that in fruit harvested in 1942 and that the severity of scald likewise had been more severe in stored apples from the 1941 crop. The connection between ethylene and apple scald was demonstrated later (1945) when satisfactory control measures were obtained by filtering the storage atmosphere through activated charcoal impregnated with bromine. This type of filter removed all ethylene from the apple vapors. The work at Cornell and similar work at other institutions has reopened the subject of storage scald of apples, with the result that a number of investigations in this field are now underway in various parts of the country.

The effects of ethylene in the storage atmosphere are not restricted to fruits and vegetables. Prior to 1941, commercial flower growers had claimed that cut flowers could not be held very long in cold storage. Investigation by the U. S. Department of Agriculture at Beltsville, Md., indicated that the storage life of cut flowers was shortened by holding them in storage rooms with certain fruits. For instance, when stored in the same room with apples, carnations developed

what is known as "sleepiness;" that is, they tended to close after having once opened. Under the same conditions roses opened prematurely and then began dropping their petals. Snapdragons quickly shed their petals, and the inflorescences of stocks (*Matthiola*) soon faded and became yellow. Narcissus flowers showed premature fading, discoloring, and shriveling. To make a long story short, carefully controlled experiments showed that it was the ethylene in the apple vapors that was causing the cut flowers to deteriorate so rapidly in cold storage. This could be prevented by storing flowers in one compartment and apples in another, and recommendations to this effect were immediately made to the industry.

The fact that decaying fruit and even decay-producing fungi evolve ethylene is of extreme economic importance. It has been reported, for example, that 1 percent of green mold decay in stored lemons will produce enough ethylene to approximately double the respiration rate of all lemons in the room. This emphasizes the need for controlling decay and the maintenance of sanitation in storage rooms. It has also been claimed that ethylene treatment of oranges and lemons reduces the "jelly-unit" yield of pectin that may be extracted from the rinds after the fruits have been stored.

The inhibition of the sprouting of potatoes by ethylene may at first appear like an advantage. In itself it is; yet the effect is accompanied by an increase in sugar, and this is not always an advantage. A high sugar content in stored potatoes is objectionable if they are to be used for "French fries" or "chips."

Much can be counted to the credit of ethylene in its physiological effects on plant material. Hastening the coloring of citrus fruits and the ripening of such fruits as the banana, pear, and persimmon, can be decidedly advantageous, as has already been pointed out. According to Marloth, ethylene has been successfully tried on bananas, plantains, tomatoes, mangoes, grapefruit, celery, pineapples, melons, persimmons, limes, lemons, dates, jujubes, pears, papayas, chayotes, cherimoyas, endive, chicory, and rhubarb. Chace and Sorber, 1936, found that ethylene could be used to speed up the natural reactions that result in loosening the hulls of English walnuts of which the kernels are mature but the hulls remain attached. Here ethylene brought about only such changes as would have occurred normally over an extended period of time. It was claimed sometime later that the extent of the use of ethylene for husking walnuts in California was second only to its use in citrus coloring. Ethylene has been found to stimulate the rooting of cuttings, but the use of rooting compounds (hormones) is now much more practicable. It has been reported that ethylene stimulates the fermenting action of yeast.

The action of ethylene in defoliating rosebushes, once a disadvantage, has now been turned into an advantage. When rosebushes are dug and held in cold storage, excessive loss of water from the plants may be prevented by defoliating. A very convenient way to do this is to treat the bushes with ethylene, or, if this is not practicable, the rosebushes may be stored along with apples. The procedure, although considered undesirable in the case of cut flowers, now becomes recommended for rosebushes. It is said that a commercial nurseryman on the West Coast has defoliated as many as 200,000 rosebushes, 50,000 in a single room, in four days' time. Customary methods would have required several weeks.

According to an article in *Tropical Agriculture*, ethylene has been used in Germany and in Italy for curing tobacco. Mature green leaves of tobacco, when treated with ethylene at the rate of 1 to 5,000 or 1 to 10,000, showed a yellow color earlier and more strongly than did those not treated. Flavor of the untreated sample was described as "sharp and poor" and the aroma "not

quite pure," whereas flavor of the treated lot was pronounced "rather full, not unpleasant" and the aroma, "pure, somewhat flowery."

Haber was able to induce earlier blooming of narcissus bulbs and the earlier maturing of sweet corn by the use of ethylene, but neither one of these uses has become a commercial practice.

As has been stated earlier, the ethylene first used was in smoke fumes, and later in fumes from a stove. It should be added that once again its usefulness in smoke has attracted notice. It has long been the custom in Hawaii to induce early flowering of pineapples by exposing them to wood smoke. As a result of the stimulating action of some substance in the smoke, the period required for maturing pineapple fruits was greatly reduced. In 1932 Rodriguez, in Puerto Rico, demonstrated that the active agent in the wood smoke was ethylene, and he was able to accomplish similar results with pure ethylene gas. Pineapple plants were thus made to bloom as much as six months before the normal time. Following this work, others treated pineapple plants with ethylene gas, with aqueous solutions of acetylene, or with pellets of calcium carbide, which generated acetylene when moistened by the dew on the plants. Some of these treatments for forcing the flowering of pineapple plants have now become commercial practices in Florida, with the result that these fruits can be produced out of season, when they command higher prices.

EXULTATION

From nameless peak to nameless peak
That men have yet to tally
My solitary song I fling
Across a nameless valley.

For here, within a secret world
By endless mountains bounded
From north to north, I stand alone
Where never song has sounded.

And in my blood the ardent strength
Of youth distills its thunder;
And as I sing, not I alone
But life cries out its wonder.

CLARENCE R. WYLIE, JR.

Book Reviews

AMERICAN SAGA

The Wallaces of Iowa. Russell Lord. xii + 615 pp. Illus. $5.00. Houghton Mifflin. New York. 1947.

IN DISCUSSING the lives and surroundings of three generations of Henry Wallaces, the author has assembled extracts from their writings, bits of anecdotal family history, and other interesting memorabilia. Many of these are in quotes in the text, others are quoted in a 14-page documentation. To these, the author has added his own first- and secondhand observations in and around the Department of Agriculture and Washington and then woven the whole more or less together with his own interpretations.

The plan of the book, as stated (p. 560), was to treat of the present Henry Wallace not as a chance growth, but as a product of an extraordinary heritage and upbringing, deeply aware of a genetic continuity in his every act. He is born about page 107. It is natural, therefore, that the 508 pages following his birth are increasingly devoted to this Henry's economic, political, and religious concepts and activities. Neither is it remarkable that the presentation is nearly, if not always, favorable to Henry Wallace and his ideas. The author was a sincere, though hired, propagandist (he calls it "special writer") for the New Deal agricultural policies. As his protagonism is frankly confessed, however, the reader can be on guard and discount some of the interpretations—if he knows which to discount and which to accept at face value.

Most readers of a book like this will have firsthand information on few, if any, of the facts and interpretations it contains. A single recognized distortion, whether intentional or not, accordingly shakes one's confidence in the whole, rendering it suspect. The reviewer had his frequently so shaken. Moreover, inaccuracies detected, even though they may be of minor importance to the main purpose of the book, have a similar effect. Thus, one does not inbreed corn to create hybrid vigor (pp. 146, 150). Again, "Some of the first hybrid seed corn" (facing p. 142) was not the first hybrid corn; that had been produced by others some years before. Neither was it the first commercial hybrid seed corn, as most readers would interpret the caption to mean; that was still to be produced, again by others than H. A. Wallace whose commercial production began many years later than the 1914 or 1915 implied on page 184. All these distortions make H. A. Wallace appear a far more important factor in corn breeding and hybrid corn development then he really was. They make a plant breeder wonder if the author is more accurate concerning other things about which he writes. Thus, for one example, on page 434 he refers to certain letters that "would have been belittling to the intelligence of an idiot child of ten" as being "forged." But can Mr. Lord's forgery allegation be relied upon any more than some of his loose statements about corn breeding? Does he know? Or is he guessing?

This reviewer may be unduly critical. He enjoyed reading of the early days in Iowa. He enjoyed reading of the bit actors in the agricultural New Deal as they passed from wing to wing across the national stage; he knew and liked many of them.

He would have enjoyed the book more, however, had it been more accurate about some of the facts with which the reviewer is familiar, and had it been written more objectively. The many quotations and extracts with which it is documented should give the book some continuing value. These are made more useful by an excellent index.

FREDERICK D. RICHEY
Knoxville, Tenn.

CLIFF DWELLERS

The Pueblo Indians of San Ildefonso. William Whitman, 3rd. vii + 164 pp. $2.75. Columbia. New York. 1947.

THE pueblos of central and eastern New Mexico, the sedentary Indian villages that lie in the valley of the Rio Grande and its tributaries, are for anthropologists tantalizing and frustrating societies of tremendous scientific interest. They lie in our very midst and are manifestations of rich and elaborate cultures. They have been known to Europeans for more than four hundred years. They have been under American control for a century. They have been painted and sketched by many an artist. They have been visited by scores of anthropologists and investigated by a few. Yet we know very little about them in detail, and we do not have a full-fledged scientific study of even one of them.

This is because the people of the Eastern pueblos have drawn the protective mantle of secrecy about their ways. There are indications that even before the coming of the white man secrecy was the mark of these cultures. White contacts have only served to intensify the old aboriginal trait. A member of the pueblo knew what he needed to know to play his part in the balanced structure of the universe as it was conceived by his people. But no more.

Today, according to Dr. Whitman, the training of children in San Ildefonso is such that the young learn in time to cease to be outwardly curious, not to spy out the secrets of their elders. "The more esoteric aspects of the teachings are unknown except to the leaders... officers of one society do not know the sacred lore of other societies to which they do not belong. Both men and women fear the possession of unauthorized knowledge" (p. 117).

It is easy to understand that such people are not receptive to prying anthropological investigation. Almost any data on the Eastern pueblos are, if reliable, useful contributions to science. Dr. Whitman's data, though scanty, are sound and presented with cautious restraint.

This book on San Ildefonso is no monumental monograph. Rather, it is a charmingly written little summary of the more superficial aspects of San Ildefonso life as observed by the author in a year's residence in the pueblo with his wife and three children. There is good material on government, fairly intimate descriptions of family life and personalities, and useful information on the externals of pueblo economics. But on religion, which, in the words of the author, "more than anything else is the integrating factor in San Ildefonso society," there is virtually nothing. Dr. Whitman did not want to get thrown out of the pueblo for asking questions out of turn. His problem was limited to observation of nonesoteric behavior. He makes no claim to definitiveness.

San Ildefonso has become famous throughout the land for its modern black-glazed pottery, formed by the women and painted by the men. An introduction to the lives of these skilled artisans will be found in the book.

E. ADAMSON HOEBEL
Department of Anthropology
New York University

SCIENCE OF THE SEA

This Great and Wide Sea. R. E. Coker. xvii+325 pp. $5.00. Univ. of North Carolina. Chapel Hill. 1947.

A PEOPLE made ocean-conscious by the catastrophe they have just lived through should welcome this popularized yet comprehensive treatise on the science of the sea. Oceanography is here wisely conceived as "the study of the sea in all its aspects." It is said, however, not to be a science in itself. That point I would modify, for any science is knowledge set to order and to use, about any focus, and no science is self-contained. The degree to which the facts and interpretations that pertain to the sea are integrated measures how justified it is to regard oceanography as a science. This book demonstrates that considerable success has been attained in such integration. In fact, it helps establish the science, while recognizing that "hardly any phenomenon of the sea is capable of satisfactory analysis without coordination of all fundamental sciences."

The history of oceanography is readably and adequately treated, with just a bit of romance and religion thrown in. The emphasis is on the evolution of the science, in terms of methods and concepts as well as of accumulated facts. General orientation is completed by a brief description of the geography of the sea.

The physical and the biological aspects of ocean science are accorded about equal space and equal emphasis. The first section deals with the sea as a solution; physical properties of sea water; bottom deposits; plans of circulation; wind-induced, tidal, and other movements; the sea and the sun. As a whole this section is accurate, informative, and reasonably adequate for all except specialists. Some complicated phenomena, such as currents and tides, are made surprisingly clear considering the purge of mathematics. Certain statements, however, seem unnecessarily conservative, and the treatment of some subjects seems unduly simplified. The representation of the distribution of temperature from pole to pole is not only schematic as stated, and unnecessarily hypothetical, but is also misleading in that it fails to show the fundamentally important north-south asymmetry in temperature distribution. Due emphasis is not granted to the importance of the bathythermograph and of other apparatus developed during the war. Oddly, the grossly macrocephalic sperm whale is chosen as "a notable example of good stream-line form." The tuna would have served much better.

In the biological section there is a fairly complete, interesting, and well-illustrated account of marine life. Particularly well done are the contrasts between the ecology of the sea and that of fresh waters. Full success was not attained—it was hardly to be expected—in the effort to eliminate the inconsistencies and the lack of logic that have always marked the classification of marine habitats and biotic assemblages. "Benthos" is used in two senses, with a differentiation only of the adjective forms, which are usually defined as synonymous. "Benthonic" is applied to any bottom life; "benthic" only to that of the continental slope. "Littoral" is adopted in the wide sense, with divisions into "intertidal" (with no mention of a supratidal or spray belt), "eulittoral" (from low tide to the limit of plant growth), and "sublittoral" (thence to the edge of the continental shelf). "Nekton" is defined as free-swimming pelagic life, yet all adult fishes are included (following, to be sure, other treatments, including that of *The Oceans*). If the concept of the "benthos" means anything, whatever it may be called, it surely should include at least the bottom-resting flatfishes and rays, the burrowing gobies, the rock-crevice sculpins and blennies, the species that are closely associated

with plants, and many other fishes. To be sure, there are many fishes that grade from "benthonic" to neritic, but such transitions are the rule. Ecological ties should mean more than locomotor habits. If the proposed division of the bottom life into "edreobenthos" (strictly attached) and "herpetobenthos" (crawling) should be adopted, it appears that there should be added a "nektobenthos" (swimming). These, of course, all intergrade.

Errors, in general, are almost negligible, except in the section on fishes. Here the incongruous and long-discredited classification of Boulenger is adopted (from Murray and Hjort). The life term of the leptocephalus of the American eel is given as two years, following an error that crept into *The Oceans*. Unaccountably, a picture of a ctenophore is presented as that of a leptocephalus. The figure labeled "flying fish" is that of a sea robin, not even that of a flying gurnard (which never flies). The flaplike lure of the goosefish is wrongly called a light organ. *Mola* is said to be rare and is otherwise wrongly characterized. *Ophiodon* is classed in the cod family.

A new edition should take care of such errors. To wind up adverse, and perhaps pedantic, criticisms, I note an overemphasis on the significance of variations in the dissolved oxygen content of shallow waters, some erroneous derivations of technical terms, and, in places, an unnecessarily cautious approach, marked by the insertion of "possibly" or "probably" where facts are well established. Naturally, examples are often drawn from, and presentations colored by, the author's personal contacts with the sea at Beaufort, N. C., and in Peru.

But who, except for a team of authorities, checked by another team, could have compiled without errors and inadequacies such a comprehensive treatise on a very complex and as yet not thoroughly integrated science? Coker set himself to the task of filling a great need, and this he accomplished very creditably. In fact, he filled a series of wants, for the book will serve well as an elementary text in oceanography, as collateral reading in courses in geography and in biology; above all, as a general source of information on a broad and fascinating subject.

CARL L. HUBBS
Scripps Institution of Oceanography
University of California
La Jolla

CHEMICAL PERSPECTIVE

Modern Chemistry: Some Sketches of Its Historical Development. A. J. Berry. x+240 pp. $2.50. Cambridge. Cambridge, Eng. Macmillan. New York. 1946.

THIS little book makes no attempt to deal with the history of the whole of chemistry, nor is it based on a strictly chronological plan. Instead the author follows the historical development of each of several branches of chemical study in separate chapters covering atomic theory, electrochemistry, stereochemistry, radioactivity, elements and isotopes, experimental studies on gases, some problems of solutions, chemical dynamics, and the development of physical chemistry. In his preface the author states:

> An attempt has been made to consider the development in historical perspective of certain branches of the science in separate chapters—each being nearly self-contained and largely independent of the others—and treated in a manner so as to be acceptable to anyone who is endowed with a moderate stock of chemical knowledge. To have attempted the writing of a more formal history of modern chemistry at the present time would have been a somewhat unsatisfactory task—it has been considered better to abandon some branches of the science altogether, rather than to attempt any sort of ill-digested completeness. . . . It is hoped that the division according to branches of study rather than according to periods of time will be found more interesting and certainly more convenient, from the point of view of the student.

The period covered by this book begins early in the nineteenth century and extends up to date as of 1944. The table of contents is unusually complete, amounting to a highly condensed topical abstract. A short list of references accompanies each chapter, representing the author's selection of the most important source material. An index of proper names and an index of subjects is also provided. The author has presented his subject matter in a very readable style while at the same time presenting a wealth of factual detail. The book is a contribution in support of the notion that a right attitude toward any subject should include a knowledge of the order in which men have perceived and tackled the problems it presented.

LUCIUS W. ELDER, JR.
General Foods Corporation
Hoboken, N. J.

OLD WINE IN A NEW JACKET

Handbook of the Trees of the Northern States and Canada East of the Rocky Mountains. Romeyn Beck Hough. x+470 pp. Illus. $5.50. Macmillan. New York. 1947.

IT WOULD be interesting to have at hand the reviews of Mr. Hough's *Handbook of Trees* that appeared on its publication in 1907, to see how in that far-off time of one's infancy reviewers responded to the first publication of this work. The comparison would surely be valid, for apparently the only difference now is in the type on the title page, though bindings may have been sturdier in those hardy days. Men's palms, too, must have been larger in the era when this work was christened a "handbook." It is an excellent book, however, giving the botanical characters and a 250-word general account for each of more than 200 trees. Surrounding the type are photographs (totaling 479 in the book, according to its jacket) and a range map on facing pages, thus wherever the book is opened presenting the complete account of some tree. After all, trees have not changed much in one of man's generations, and unfortunately there is still validity in such a comment as "The Hemlock . . . was once one of the most abundant trees of the northeastern forest, but such is the value of its bark for tanning purposes that they have nearly all been destroyed, only scattering trees now remaining." Mr. Hough, however, deliberately missed the forest to show trees, and those who are interested in trees will indeed have a good chance to see them in this book, though one will have to be careful in relying on it for a vocabulary with which to talk up to technical foresters. The trees are the same, but the scientists in forty years, it can be taken for granted, have thought up a few new names and discovered at least some corrections in classification.

HOWARD ZAHNISER
The Living Wilderness
Washington, D. C.

THE AGE OF ANXIETY

The Problem of Reducing Vulnerability to Atomic Bombs. Ansley J. Coale. xii + 116 pp. $2.00. Princeton. Princeton, N. J. 1947.

SEVERAL books have been written upon atomic energy since the Smyth Report in 1945. The vast majority of them have described the Smyth Report in simpler words, with a modicum of speculation regarding the influence of atomic energy on various phases of life. Few books, however, have been of such importance that they stand out as key publications for policy making and as directives for future efforts. The Smyth and the Acheson-Lilienthal reports were definitely important publications regarding atomic energy, but both of them failed to present a concise and

well-worked out scheme for a nation faced with the possible use of atomic energy in an all-out atomic war. This lack has been remedied by Coale's book, which was prepared under the direction of the Committee on Social and Economic Aspects of Atomic Energy, of the Social Science Research Council (Riefler, Brodie, Likert, Marschak, Notestein, Ogburn, Rabi, and Smyth). An objective attitude is maintained throughout the book.

The four sections, labeled chapters, begin with Reduction of Vulnerability Under an Effective Agreement, which is a detailed study of the vulnerability of a nation under a surprise attack from a supposedly peaceful and friendly country. The aggressor nation would have secretly diverted fissionable material to manufacture atomic bombs. Important defense measures would include maintaining the armed forces at a high peak, stock-piling strategic materials, and reducing the vulnerability of the country to attack. An entirely new mode of warfare, of disposal of troops and materials, and a new method of handling munitions would be essential. There is strong evidence that the war might be won or lost on the munitions stock-piled at the time of the attack. The disruption resulting from an all-out atomic attack might leave only especially prepared, secret, underground production centers capable of fighting back.

The section on Reduction of Vulnerability when Atomic Armament is Unlimited is very pertinent to present world conditions. The use of X-thousand atomic bombs in an all-out atomic attack presents two problems: one, a loss of the war if special provisions against impending attack have not been strictly enforced; and, two, the probable loss of humanity if radioactive by-products cover the earth. The latter point is not discussed to any extent. One solution would be to stagger the use of atomic bombs so as to give time for the radioactive products to decay below the lethal point for the total atmosphere. There is always the possibility, of course, that one nation would disregard such an action and precipitate a biological crisis. Relocation of industry and living centers is mentioned as a means of reducing casualties. The magnitude of such a task, as described, precludes any hope of its being done until after at least one atomic war has been fought. The casualties in such a war would be high, perhaps one-third of the total population of the United States in the first week or so.

Technical Considerations goes into detail on points covered by the Smyth report and subsequent releases on the attacks on Japan and the Bikini tests. Blast, radiant heat, and penetrating radiation remove the atomic bomb from the category of any previously used weapon. Furthermore, bombs can be made many times more destructive than any used so far. More powerful bombs would prohibit the use of underground emplacements for defense as well as for living quarters. Knowledge of the location of such an underground point would be all that would be necessary to ensure its destruction. The method of delivery is assumed to be, primarily, the plane. The use of supersonic missiles such as the V-2 type of rocket would make any attempt at interception almost useless.

The important fact is brought out that defense against chemical missiles is considered partially successful, but that only one atomic warhead getting through means destruction of the target and the surrounding area. First-used defenses are always ineffective, which, in the case of atomic warheads, almost eliminates any form of defense against them. A 100-percent effective defense from the beginning of an attack is technically and mechanically impossible within our present scope of knowledge. Radioactive and biological poisons are very briefly discussed. Most scientists believe that they are just as effective as the atomic

bomb—if not more so. The unshielded-pile jet plane is not emphasized. This latter weapon would be very efficacious.

The last chapter, or section, is on the need for research and analysis. The weakness of modern civilization, faced with the threat of atomic warfare, lies, of course, in its centralized location of communications, government, and production. The discussion of this factor and of decentralization convinces one that atomic warfare and an advanced civilization are mutually incompatible.

This well-written, important book is a must for anyone interested in his future chance of survival. The general conclusion is that an atomic war would be so destructive that any country indulging in it probably would not recover. The greatest handicap to an effective defense seems to be psychological. Everyone assumes that "it can't happen here." Such an attitude almost automatically wipes out really adequate countermeasures. Although the United States is used as an example of the attacked nation, there is very little doubt that an aggressor nation would be confronted with similar problems. Coale emphasizes the fact that no nation would risk an atomic war unless it were reasonably certain that retaliation in kind would be impossible. This premise, however, has been held by all aggressor nations and has always proved futile. It should not be overlooked that even in the case of the defeat of a country by atomic warfare, the radioactive by-products, the biological pests released, and the underground resistance using such weapons would eventually destroy the attacker just as efficiently as if he had been destroyed in the beginning. The question is one of time, and of more academic interest than technical at the moment.

THOMAS S. GARDNER
Scientific Department
Hoffmann-LaRoche, Inc.
Nutley, N. J.

BIRDS

Darwin's Finches. David Lack. x + 208 pp. Illus. $4.50. Cambridge. Cambridge, Eng. Macmillan. New York. 1947.

ADAPTATION of form to function has been a favorite theme for the biologist. Textbooks and manuals explain how the larger groups of birds show differences in feet, beaks, etc., adapted to their ways of life. The finches of the Galapagos Islands came first to attention from Darwin's *Voyage of the Beagle*. They interested him immensely and had a prominent part in developing his ideas of natural selection. Contrary to ancient development of the larger groups, this is a relatively modern branch in which *species*, closely related, have diverged to show surprising differences in beaks and feeding habits. A cuckoo, mockingbird, warbler, martin, and two flycatchers, comprising the rest of the Galapagos land birds, are closely related to South American forms and are believed to have reached the islands accidentally at various periods.

Lack presents a concise summary, from a brief general description of the islands and their human history to detailed analyses of specimens in various museums and of behavior as reported by all expeditions. Colored illustrations of seven species are reproduced from Gould's work, which had first described the birds from Darwin's collection.

Previous authors have held that beak differences in species of *Geospiza* are not of adaptive significance in regard to food. Lack feels that there must be small differences that are sufficient, at least at some period, to prevent competition between species. Earlier analyses failed to give enough weight to food habits during the breeding season. Lack considers also that beak differences play an essential role as recognition marks. Similar differences in

bill size for other species of island birds are discussed. The beak of the Galapagos mockingbird varies in length from 20 mm. on some islands to 33 mm. on others, a range which scarcely seems possible to attribute to differences in food habits.

Camarhynchus pallidus, the woodpecker finch, climbs up and down tree trunks. It has a somewhat elongated beak, with which it drills for insects but, lacking the long tongue of a woodpecker, it takes a cactus spine or slender twig and probes for insects. This habit, observed by Gifford in 1919, by W. H. Thompson, and by Lack, is said to be one of the few recorded uses of tools by birds.

Lack recognizes fourteen species in four genera. He seems not to indicate any formal technical changes in status but has some notes in Table IV. Two forms collected by Darwin are regarded as extinct subspecies, but are not formally named. He feels that hybridization has not been frequent, but regards intermediate specimens as unusual extremes. The final chapters deal with origin of the Galapagos fauna, origin of species and subspecies, persistence of species, and adaptive radiation. There is a good index and an extended list of references.

O. A. Stevens

Department of Botany
North Dakota Agricultural College

WEALTH OF THE OCEAN

Raw Materials from the Sea. E. Frankland Armstrong and L. Mackenzie Miall. xii + 196 pp. Illus. $3.75. Chemical Pub. Brooklyn. 1947.

THIS book describes the separation of economically important substances from the sea and includes "general reference to the chemical problems which the oceans represent and to the various elements in them in minor quantities." The first chapters—Something about the Oceans, Chemicals in the Sea, and The Bio-chemistry of the Ocean—are compilations of marine fact. The remainder of the volume considers the separation of materials from the sea: Solar Salt, Bromine from the Sea, Magnesium from the Sea, Iodine and the Seaweed Industry, Potassium Salts, and Potable Water from Sea Water. Many references are given; an appendix on analytical methods and an index complete the work.

While this volume is neither nontechnical enough to be a popular work nor critical enough to satisfy the requirements of a source book, it does offer a rounded orientation toward its subject. In this respect it represents a contribution to chemical literature, but in others it does not reach the standard common to the field. Editorial and typographical errors are frequent, and the appendix on analytical methods serves little purpose since this twelve-page précis of analytical procedures for twenty-four elements cannot be used in the laboratory and offers no critical focus for the reader.

Howard S. Mason

National Institute of Health
Bethesda, Md.

THE FRENCH-CANADIAN OUTLOOK

A Brief Account of the Unknown North Americans. Mason Wade. 192 pp. $2.00. Viking. New York. 1946.

MASON WADE has written for the general public a little book which contains some of the observations and conclusions that will later appear in what will prove to be a "monumental" work on the French-Canadian mentality. Such an enterprise is always risky: the observations are likely to appear a little short, the conclusions gratuitous; and the plan itself is revealed as through the large end of a

telescope. One may not, therefore, quarrel with Wade over some of his more evident simplifications, nor reproach him for avoiding some rather involved issues, but rather wait until the promised big book is published. He has probably brought together in the present volume the most extensive existing documentation on this subject, and has obviously done so in a spirit of objectivity and fairness.

Wade's training as a historian and his previous record as a writer provide him with an especially desirable background for this delicate task. His interest in the work of Francis Parkman early brought his attention to the conflict between French and English in the St. Lawrence Valley. This has enabled him to bring out the historical filiation of some of the debates that endure in one form or another to this day. For instance, in many passages, he picks up the thread of ultramontanism in the French-Canadian clergy and people and shows that it amounts to a veritable tradition and is to be considered one of the basic traits of this people's mentality. This is one of the most important themes in his book and one of the most valid explanations of many an attitude of French-Canadian leaders of the past and present.

The first chapter is a most important one to those who seek to understand French Canadians, inasmuch as they "live in and on their past to a degree almost inconceivable to the average English-speaking North American;.. tradition is a stronger force there today than anywhere else in North America." What French Canadians think and know of their past is almost as important, as a motive, as what really happened. Wade has had to do some first-rate debunking to show that the wishful thinking of both French- and English-speaking historians has led to the writing of "histories of Canada so dissimilar as to suggest that they were histories of two different countries." Crusading colonization, romantic gentility, fearless adventure, bold resistance, desperate courage—such are the elements of his history to the French Canadian, to whom the inherent weaknesses of the French Regime do not appear any too clearly and even less the contrast between its social structure and that of New England, say. Wade justly remarks upon the "hierarchical society" of New France and on how it has tenaciously survived. In fact, the picture painted by Pehr Kalm in the latter part of the eighteenth century remains true in its basic elements. This, in a concluding chapter, is summed up in the following sentences:

> French-Canadian society varies notably from the North American norm. It may well be compared to an iceberg. The one-ninth that is above water, the elite of priests, lawyers, doctors, scholars, and other highly educated men includes some of the most cultivated and charming human beings on this continent. Most of its members are the equals and some the superiors of the best that English-speaking North America produces. The humanistic discipline of the classical colleges has preserved them from the narrow and limited outlook increasingly characteristic of products of the English-speaking educational system, as premature specialization and overemphasis on technical studies have become more and more dominant. Perfectly bilingual, at home with the cultural heritages of France, Britain, and the United States, and adding Gallic gaiety and wit to the North American mixture of traits, the best of this elite is a leavening element in Canada, and can be one throughout North America if it develops a broader outlook and continues to strengthen its technical training. But the submerged eight-ninths of the social iceberg, the great mass of the French Canadian, are underprivileged economically and intellectually. Their standard of living is well below the North American norm; and has become dangerously so as more and more of them abandon rural life with its low cash income compensated by good food and health, in favor of higher wages with poorer food and housing in the overcrowded cities, where malnutrition and tuberculosis have made great inroads on the traditional French-Canadian vitality.

To many of us the above seems somewhat oversimplified, and there have been

rather vigorous and not entirely judicious protests. But it may be that we live too close to ourselves to get the proper perspective.

The first contacts between French and English, which are described in the second chapter, were not all unhappy. It is an established fact that the majority of the conquered French cared more for the land they inhabited than for allegiance to France. In fact, it is noteworthy that no movement of any significance was ever undertaken in the direction of a return to France, and that the French Canadians struggled to remain distinct, to maintain their language and religion, not to free themselves from British rule.

The period from 1790 to 1867 is much more difficult to summarize and involves a number of new elements. The author does his best to dispel some of the more current misconceptions concerning the French Canadians and urges that "it never be forgotten that the French Canadians are North Americans, and that they have been exposed to North American influences longer than have either Americans or English Canadians."

The crucial event of the difficult and unhappy pre-Confederation period is the suppressed revolution of 1837–38, which the author characterizes in these Churchillian terms: "Never has so little bloodshed been so well remembered." "Ethnic hatred," however, was not the only issue, and the economy that emerged from that crisis was not one to cause French Canadians to rejoice. Contradictory ideals, culture, religion, and economic standards made it hard for "two peoples to make a nation." That they nevertheless did, through a common, if mutually ignored, desire to achieve a livable adaptation to their North American environment.

The third period, ending with World War I, is notable, however, for a decadence of the spirit of Confederation, whose "survival has frequently been threatened by the failure of later leaders to share the tolerant spirit of the fathers of Confederation." An excessive cultivation of the past and a spirit of grievance on one side, lack of understanding and economic oppression on the other, were such that "relations between French and English Canadians reached a new low in the closing years of the First World War."

During the interval between the two world wars, the French-Canadian isolationists turned briefly to separatism as a goal to be achieved in Quebec, only to defeat themselves during World War II. The all-out imperialists and implicitly racist money-makers also encountered their day of liquidation in the changing world economy.

Another French-Canadian myth is the sacredness and the "goodness" of the soil, coupled with "the resistance of the class-proud elite to any occupation which involved rolling up one's sleeves and getting one's hands dirty." Attachment to the soil and the moral values rural life is supposed to stand for are an important part of the French-Canadian emotional background. On the other hand, the "classical" pattern of education tends to strengthen the social hierarchy. These and many other factors of the French-Canadian complex are taken into account by Wade in his survey when, in his final chapter, he attempts to draw together the threads of French-Canadian history and social and economic life.

The picture, as it stands, therefore, is not meant to please or to displease, but mainly to inform. The book should prove extremely useful to many categories of readers. As the author points out in his concluding remarks: "The problem of Canadian union is merely a special case of the great world problem of our time." And that is everybody's business.

Pierre Dansereau

Service de Biogéographie
Université de Montréal

Comments and Criticisms

GHOST WORDS

Mr. Thomson King undertakes to show your readers that life is a "separate entity." By separate he means that it is not matter and not energy, which, he says, are the only other two "entities;" as it is not either of them, it must be a separate "entity." Matter and energy, he says, "have their usual scientific meanings;" while by "entity" he means something "having reality in fact, which is separate and unique in itself."

Some of your readers, of whom I am one, will doubtless consider this alleged definition not wholly satisfying. Pushed into a corner, Mr. King would be compelled to confess that he does not know how to define "entity," that it is but a ghost word, a concoction of the medieval Schoolmen, without any real content, and satirized by Butler in "Hudibras,"

> Where entity and quiddity,
> The ghosts of defunct bodies, fly.

Looking in the *Century Dictionary*, we find that it is "an ontological chimera" and "an independent ens."

Once in a class at college, I was assigned to write an essay on matter. I spent an hour or two in the university library copying down the opinions of many learned men on the subject; my conclusion was that there is no true definition of matter. Mr. King slides out of this dilemma by saying merely, "It has its usual scientific meaning."

Mr. King's essay, as an essay, may have some collateral value; but, as to the nature of life, he has told us nothing and our knowledge remains what it always was: we do not know what life is and we have no way of finding out. The nearest thing I know to a definition is that given in Wilhelm Bölsche's "Stunden im All" (and doubtless by others, too) in which he compares life to a candle flame; Mr. King can best tell whether that meets his definition of an entity. The string of startling scholia that draws out of his main thesis will, of course, fall to the ground along with it.

Even a god could not give us a true definition of life, for it would be beyond our comprehension; and, as the author of "Shakespeare" [*sic*] succinctly put it,

> We fools of nature
> So horridly to shake our dispositions
> With thoughts beyond the reaches of our souls.

WETMORE COLLES

Rosharon, Tex.

LE PROBLÈME DE L'UTRICULAIRE

Permit me to express my appreciation of an article in the May number of THE SCIENTIFIC MONTHLY, by E. W. Gudger, on *Utricularia vulgaris* L. as a fish-catching plant.

Am more interested from the botanist's view than from that of the ichthyologist, but found the article very interesting and rather complete, conservative and readable.

Have had occasion to study the plant at first-hand, as I own several small lakes where two species of *Utricularia* are in bloom in July and August. These are *Utricularia vulgaris and U. radiata.* Will watch these with even more interest now.

A recent English authority goes further in stating that *Utricularia vulgaris* catches its prey and completely digests it in twenty minutes, then sets the trap for the next victim (Brimble, L. J. F. *Flowers in Britain.* London: 1944). Brimble is joint editor of *Nature* and Lecturer, Universities of Glasgow and Manchester.

Thanks again for publishing readable articles of this nature.

S. G. DRUSHEL

Edna, Texas

OF CHAOS AND COSMOS

In the June issue Mr. John L. Chambliss' "A Layman Looks at Science" states Sir James Jeans's tidal disruption theory as explaining the origin of the solar system by "the *chance* approach of a passing star." Now, obviously, all that the theory postulates is the approach of a star to the sun near enough to detach a fragment capable of segregating into the planetary system, and the theory is entirely unaffected by the cause of the approach. Whether the event was controlled by Chance or by Design is, in respect of the result, of no meaning. It follows, therefore, that any eventual confirmation of Jeans's hypothesis would afford no ground for Mr. Chambliss' fear that, "if we thus account for the origin of the solar system and this earth we live on, then the idea of a Guiding Intelligence behind the universe goes up in a puff of smoke."

Natural science is concerned with the forces associated with the sun and the visiting stars, but the Power directing those forces is the subject of an inquiry lying entirely outside its scope.

HENRY H. KNOX

Santa Barbara, Calif.

PSYCHOLOGICAL PHENOMENON

It is difficult to express soberly my disappointment concerning Mather's review (SM, May 1947) after reading Du Noüy's *Human Destiny*. Mather's only important criticism, that the author "at times seems to base certain conclusions on the absence of knowledge rather than upon inferences from verifiable data," is sound, but understated.

If the book is not to be called intellectually dishonest, it must be classed as an example of the psychological phenomenon described by Carlson in "Science and the Supernatural" (SM, August 1944): "The two [science and the supernatural] are in their very essence imcompatible, but they can apparently coexist in some scientists of the first rank. Man is, indeed, a perplexing animal"

Although the book is confused and contradictory, its chief error is quite clear. This is a misconception of the scientific attitude, a claim that science is no longer deterministic, and has no laws other than statistical ones. On page 26 is found this amazing statement: "*All* our scientific laws at present rest on chance, that is to say, on the hypothesis of an absolute disorder at the base." This denies the existence of gravitational and other field theories, and most other physical theories, including the basic principles of the conservation of momentum and of mass-energy, yet its author is said to be "one of the foremost biophysicists of our time."

Du Noüy also makes mistakes in applying the calculus of probabilities, which he claims is the basis of scientific law. The first is the assumption (p. 33) that all dissymmetries of molecules are due to chance, not to the nature of the bonds between atoms. The last is the conclusion that an event with an extremely small, but finite, probability never could happen, even in an infinite time (p. 35). This confusion of infinity with something finite is repeated on pages 66, 121 (twice), 122, 177, 192, and 193.

Having denied the existence of the first law of thermodynamics, Du Noüy proceeds to misapply the second law. Although the limitation of this law to *isolated* systems is correctly stated in a footnote on page 41, it is repeatedly applied to nonisolated systems—as living things always are—thereby arriving at false conclusions like (pp. 41–42) "The laws of chance forbid any evolution other than that which leads to less and less dissymmetrical states." If this law be thus misapplied, one need not go to living matter to find violations of it. Even such an unthinking thing as an electric motor is a perpetual motion machine—as long as it is connected to a power source! If a student in a thermodynamics class showed such poor understanding of the second law he would be promptly "flunked." When "one of the foremost biophysicists of our time" does it, his book becomes a best seller, and is praised by Nobel prize-winner Millikan as "a book of . . . fundamental grasp and insight." Carlson was right; man *is* a perplexing animal!

Though he distorts the deterministic attitude in his attacks on it, it is significant that Du Noüy himself, in the work that brought him his scientific reputation, was using the deterministic point of view. See, for example, the chapter ' Surface Tension of Colloidal Solutions, and Dimensions of Certain Organic Molecules" which Du Nouy contributed to J. Alexander's *Colloid Chemistry*. It shows the same materialistic attitude as the other chapters.

If space permitted, I could cite many more instances in *Human Destiny* where its author shows a misunderstanding of the aim of science, modern theories of evolution, even religion, although the book is obviously an apology for religion However, the book is not all bad. The discussion of education in Chapter 15 has some good points, though even this is marred by many dogmatic assertions on debatable topics.

GEORGE A. FINK

Easton, Pa.

ETERNAL TRUTHS

It is indeed refreshing to read the meditations of the young surgeon expressed in the poem "To a Cadaver," by Arden Almquist, in the April issue of THE SCIENTIFIC MONTHLY. In this age when many misguided souls close their minds to eternal truths, refusing to be convinced by facts evident even in their own poor experiments, it is heartening to recognize a man who loves all men for the very dignity that is theirs as children of God.

HARRIET GRIFFIN

Brooklyn, N. Y.

VALUES

I write, as a humanistic philosopher, to express my hearty admiration for, and concurrence in, "The Scope of Science," by Ralph W. Gerard [SM, June 1947]. And, incidentally, to congratulate you on the greater interest afforded by the recent widened scope of your journal.

J. A. LEIGHTON

Worthington, Ohio

Technological Notes

Too Much of a Good Thing. Experience as an "information specialist" has made me sympathetic with the efforts of the people who are trying to write informative newspaper stories about the work they are hired to publicize. I am particularly interested in attempts to tell people about scientific developments and applications. Most of us believe that more and better science writing is needed.

Perhaps we are wrong—at least about "more" writing. Anyhow, the combination of a hot August afternoon and a bale of releases has made me skeptical.

When I studied civil engineering at Ohio State University the chairman of the department, Professor "Chris" Sherman, instructed us in some details of life as well as of technology. The technology is largely gone, but some of the life lessons remain, with this in first place: If we are doing any engineering work we want every technical detail to be the best possible. We want accurate plans, excellent construction, intelligent supervision, precise inspection. But the most important engineering decision of the entire project is whether the work ought to be done at all.

That criterion comes to mind as I look over eighteen offerings of the "Public Information Service" for the annual convention of the American Society of Civil Engineers in Duluth last July. Obviously, the public-relations people didn't expect every editor to use every story. There was repetition. Nearly every piece mentioned the "94-year-old society, oldest national engineering organization in the country." (Though 1852 from 1947 leaves 95.) A general story gave names and titles of papers, and other articles gave details of individual talks. There was variety and information, but the depressing thought remains that most of the carefully prepared material reached editors' wastebaskets instead of readers.

It appears that the ASCE program was interesting. There was reassurance—Minnesota's iron ore won't give out for a long time, for when we need it we can concentrate the lean deposits, even burning nearby peat for power, as the Russians are now doing. There was the usual prodding of the members to assert themselves as citizens as well as engineers. Timber management was urged, as well as engineering knowledge of plywood; diversion of water to useful places was compared to a blood transfusion; war haste in placing concrete was deplored; the Garrison Dam project was called "heart and keystone" of Missouri River development; Maine's building of a toll road, like Maine politics, was suggested as a national pattern (wait and see whether it pays, though); the U. S. Engineers are learning how to build on "permafrost," the permanently frozen ground up North; construction costs can't come down to prewar—we can't pay the national debt if they do; chemical treatments make earth highway bases almost prescription items; bold city planning is needed to free us from the tyranny of gridiron street patterns; the building industry needs a research program; Duluth-Superior harbor is next to New York's in tonnage; Minnesota has a fifteen-million-dollar sewage-disposal program.

Valuable items those. Good for people to know. But eighteen separate releases about them make the dose rather heavy.—M. W.

The Brownstone Tower

MEMBER participation is the key to a more interesting, more informative, and more authoritative SM and to a stronger, more influential A.A.A.S. The trend is in that direction, as indicated by developments that occurred during the summer.

Our plan to re-establish Science on the March, beginning in the January 1948 issue, on a broad, firm basis of member participation is getting a splendid response. We wrote to the presidents of sixty societies affiliated with the A.A.A.S. requesting them to appoint one or more reporters to represent their societies in Science on the March. At this writing in August many reporters have already accepted appointment, and many others are to be appointed at forthcoming meetings of the governing bodies of certain societies. Every reporter is to submit at least one short article each year describing some significant advances in the field of science covered by his society. Thus we shall get more comprehensive coverage of all fields of science than was heretofore possible. Moreover, these reporters, all chosen because of their familiarity with their subjects and their ability to write in a nontechnical manner, may write principal articles or call attention to articles that should be written for the SM. Their services as advisers to the editor may be just as valuable as their contributions to Science on the March.

Another form of member participation is developing through the first photographic competition being sponsored by the SM and the Smithsonian Institution. Many requests for information have been received, and entries for the competition are beginning to arrive. Thus the SM will make possible the public showing of selected prints of special scientific merit, not only in the Smithsonian Institution and at the Chicago meeting, but subsequently in institutions that may wish to borrow the prints for limited periods. These exhibitions, together with the publication of selected prints in the SM, should call attention far and wide to the uses of photography in scientific research.

The SM has already served as an outlet for other forms of expression by scientists. Examples of serious poetry and light verse written by scientists have appeared regularly. What about the graphic arts? Here again member participation may provide satisfaction to the participants and increase the attractiveness of the SM. We should be glad to receive artistic black-and-white sketches of a literal or symbolic nature that might be used as headpieces or tailpieces or elsewhere in the SM as space and appropriateness may dictate. Any scientist gifted in sketching can see by looking at the present SM how much its appearance could be improved by appropriate artistic decoration. We should be glad to have the ideas of members on this subject whether they can contribute sketches or not.

The steadfastness of our readers will soon receive a severe test—one that touches the pocketbook. On page 294 of this issue is the announcement of an increase in annual dues to the A.A.A.S. from $5.00 to $6.50, effective for the SM to be delivered in 1948. Our Executive Committee held off this increase as long as possible, but the effect of rising prices could not be denied. Let us work together to make the SM well worth its increased cost.

F. L. CAMPBELL

THE SCIENTIFIC MONTHLY

VOL. LXV November 1947 NO. 5

THE STORY OF EL PARÍCUTIN

By FRED M. BULLARD

The observations on El Parícutin were made in 1944 and 1945 by Professor Bullard (Ph.D., Michigan, 1928) under a research grant from The Geological Society of America and the University of Texas Research Institute. Dr Bullard is Professor of Geology and Mineralogy at The University of Texas. A native of Oklahoma, he has spent most of his academic life there and in other parts of the Southwest.

A VOLCANO is a vent in the earth's crust from which gaseous, liquid, or solid material is ejected. Lofty cones are frequently formed by the accumulation of the ejected material around these vents. Indeed, the most lofty mountains on the face of the earth are volcanic cones. Alaska and Mexico have numerous active volcanoes, but the United States was without an active one until the explosive eruption of Mount Lassen in California in 1914. The activity of Mount Lassen extended over a period of about three years and was followed by quiescence, the only indication of activity today being the hot springs and fumaroles at the base of the cone and the gases that rise quietly from the crater. Although the number of volcanoes in North America, including both active and extinct, must number in the thousands, only two new vents have come into existence in North America in historic times. The birth of a new volcano is, therefore, an event of rather unusual significance. A volcano is essentially the result of a gas explosion, a remnant of the gas evolving process that has been going on since the earth separated from the sun. Not only does an active volcano enable us to study geology in the making, but it affords an opportunity for observational data on some of the problems fundamental to our concept of the origin and history of the earth. To be able, therefore, to study the entire life history of a volcano is indeed a rare opportunity.

Both the new volcanoes of North America are located in western Mexico. On September 29, 1759, 188 years ago, the inhabitants of Jorullo, a small Indian village southeast of Uruapan in the state of Michoacán, Mexico, were alarmed by the sudden eruption of material from an opening in a nearby field, which was being cultivated at the time. Shortly, the surrounding land was covered with ash and black cinders, which ruined the crops and caused the buildings to collapse. As the eruption continued, three extensive outpourings of lava laid waste a broad expanse of fertile land. A main cone, approximately 1,300 feet in height, and three smaller subsidiary cones were formed. After a few years (the chief activity was the first year) the eruption ceased, and no further activity has occurred at this vent. Our knowledge of the

actual eruption is from notes left by the Spanish priests who journeyed from Morelia to witness the eruption, and from the writings of Alexander von Humboldt, who visited Jorullo in 1803.

Common as such cinder cones are in Mexico—there are literally hundreds in the region—no repetition of such a dramatic event as the birth of a volcano took place until February 20, 1943, when, only 65 miles northwest of Jorullo, the second volcano to come into existence in North America in historic times was born. Named Parícutin for a small Tarascan Indian village (population, 500) 1½ miles from the vent, it is roughly 200 miles west of Mexico City and 20 miles southwest of Uruapan, a city of 30,000 inhabitants, connected with Mexico City by a paved highway and a railroad as well as air lines. From Uruapan, taxis and buses reach the outskirts of the now lava-covered town of San Juan de Parangaricutiro, 3 miles from the base of the cone. Here, customarily, horses are obtained, and the remainder of the journey is made on horseback. The area where Parícutin Volcano appeared is a basin, about a mile and a half in diameter, bordered by volcanoes (cinder cones) on the north and east and by the high mountain mass (also volcanic) of Tancítaro (approximately 13,000 feet) on the south and west. The village of Parícutin, which is now completely covered by ash and lava, was in one edge of the basin, and the Indians of the village cultivated the land in the basin for a living.

The stories of the beginning of the volcano are varied. The first indication that something was about to happen was on February 5, 1943, when strong earthquake shocks were felt in the surrounding

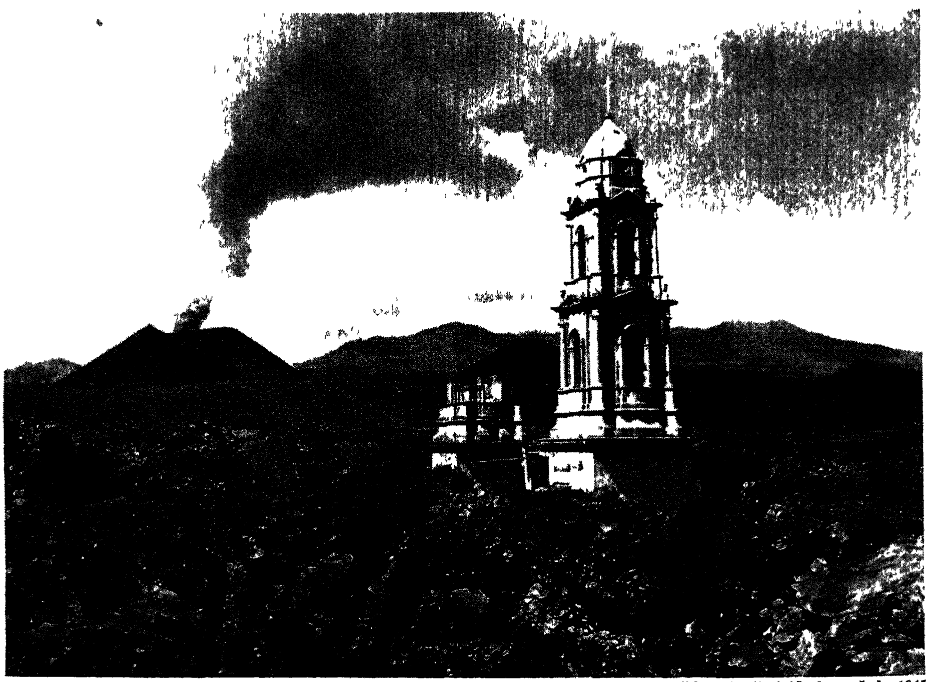


Photo by Tad Nichols, July 1945

A CONTEMPORARY POMPEII

THE TOWN OF SAN JUAN DE PARANGARICUTIRO WAS BURIED UNDER 30 FEET OF LAVA IN JUNE 1944, LEAVING ONLY THE CATHEDRAL TOWERS PROJECTING ABOVE THE LAVA FIELD.

area, alarming people in towns 20 or more miles distant. These shocks continued, and on February 12 the newspaper reported 30 shocks in the nearby town of San Juan de Parangaricutiro. On February 19, 300 tremors were reported. The inhabitants of Parícutin and San Juan de Parangaricutiro were seriously alarmed by the frequency of these tremors, although earthquakes are not particularly uncommon to the region. On the morning of February 20, Sr. Dionisio Pulido, a Tarascan Indian from Parícutin, with his wife and a friend, left the village to spend the day in the basin, where he had a 9-acre plot of land. They took with them certain supplies to prepare for the spring plowing. Suddenly, as they worked, they began to hear strange rumbling noises beneath the ground; these increased in intensity during the morning and were described as similar to the roar of a freight train A little later, Sr. Pulido and his companions saw, with great surprise, narrow columns of white gas, which they described as smoke, rising from the edges of a small depression that had just appeared in the Pulido plot. By four o'clock the small columns of gas had changed to thick black clouds, accompanied by violent explosions, dust, rocks, and red-hot fragments Terrified, the Indians hurriedly abandoned the scene. After warning their neighbors in Parícutin, they went to report their strange experience to the authorities at San Juan de Parangaricutiro. By the time they arrived the explosions could already be heard, and the dark, dust-filled gas column could be seen rising many thousands of feet into the sky. During the night the roar of the explosions and the glare from the red-hot material kept the panicky population of Parícutin and San Juan de Parangaricutiro awake. Groups of frightened men and women gathered in the churchyard to witness the magnificent spectacle and to ponder its meaning. Early the next morning some of the more curious ventured into the basin to observe the activity at close range. On arriving at the scene they found a black cone, already 120 feet high, with an opening in the top through which hot gases, ash and cinders, solid fragments, and molten bombs were being ejected in violent explosions at intervals of one to two seconds. Dr Ezequiel Ordonez, veteran Mexican geologist and student of volcanoes, reached Parícutin on the evening of the third day of the eruption. He describes the eruption, as he first observed it, in the following words: "Amid the almost continuous explosions I could see many tons of incandescent rocks being hurled high into the darkness of the night, and the flames attending each explosion brightly illuminated the big column of vapor and gases that were issuing from the huge vent"

During the first few weeks in the history of the volcano, the material ejected was largely fragmental, consisting chiefly of bombs (pasty masses of lava which cool in flight) and blocks (fragments of the wall rock of the conduit). The bombs ranged in size from a few inches up to masses several feet in diameter. Most of them were solid when they landed, but occasionally they were still soft enough to flatten upon impact with the ground. In addition, the eruption column, black with ash and cinder particles, boiled out of the crater like smoke from a ship's funnel and rose to a height of 15,000–20,000 feet before it spread out and drifted with the prevailing wind. From the eruption cloud there was a constant rain of ash particles, which filled the air and produced a bluish haze that gave the impression of an approaching storm. Near the base of a cone the fragments are quite coarse, but the finer material drifts many miles before it finally settles. The heaviest ash falls from Parícutin were in April 1943, when an appreciable amount fell in Mexico City, more than 200 miles distant. The tempo of the explosions varied from one

to two seconds the first few days to three to four minutes during the second and third months. Later in the first year, the interval between explosions became longer, and the explosions were more irregular than during the early months. It should be stated, however, that there was continuous activity during the first two years. During the past two years there have been periods, ranging from a few days to a week or more, during which there was little or no explosive activity in the main crater. Lava, however, has continued to flow during much of this time.

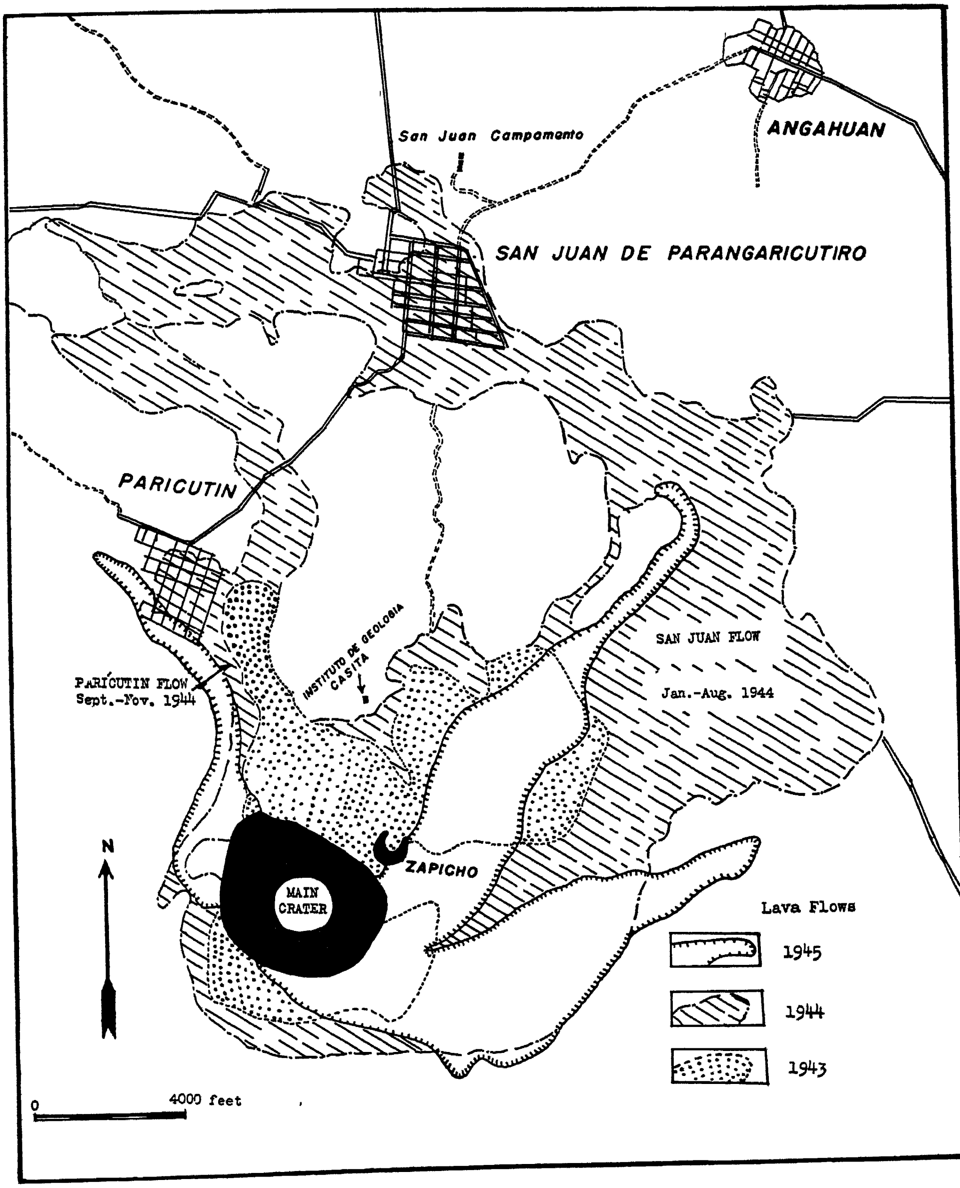
At night the volcano presents a magnificent spectacle. During the early months, when the explosions were frequent and continuous, the night spectacle was at its best. With each explosion literally thousands of red-hot fragments were thrown to a height of 2,000–3,000 feet above the crater rim, and, as they reached their zenith, they seemed to stop before beginning to fall, showering the cone like a giant skyrocket and leaving a trail of fire as they cascaded down the sides. So abundant were these fragments that frequently the entire cone was covered with interlacing fiery trails, which outlined it against the blackness of the night. The effect was complicated by the fact that in the early months four or more subsequent explosions would take place before the fragments from one explosion had landed. Thus some bombs were going up, others were just reaching their highest point, and others were falling, presenting a spectacle that held the attention of the observer for hours at a time.

During the first three months ash falls caused much inconvenience and considerable damage in Uruapan and other towns in the region. In the immediate vicinity of the volcano the ash killed the trees, filled the springs and wells, collapsed the roofs of buildings, and laid waste the land.

Photo by the author, September 6, 1944

LAVA FLOW OF SEPTEMBER 1944 ADVANCING THROUGH A FOREST

NOTE THAT THE TREES WERE FREQUENTLY PUSHED OVER AND BURIED BY THE ADVANCING LAVA



LAVA FLOWS FROM PARÍCUTIN VOLCANO

MAIN CONE AND 1943 FLOWS FROM A MAP BY INSTITUTO DE GEOLOGÍA; 1945 FLOWS (TO MAY) AFTER WILLIAMS.

Parícutin village was soon buried by the ash and cinders, and in June 1943 only the roof tops were visible above the cover of ash. At this time the Mexican government evacuated the inhabitants, moving them to a location near Uruapan. The thickness of the ash, as mapped by Dr. Howel Williams in May 1945, varied from 10 feet at a distance of 1 mile from the cone to 3 feet at a distance of 2 miles. The greatest extent of ash is to the east of the volcano, where a thickness of 6 inches is to be found 10 miles from the cone.

The ash falls were heaviest during the

first few months in the history of the volcano, and this period may be called the cone-building stage. This stage lasted for about nine months, and during this time the cone grew rapidly. It was also at this period that the conduit of the volcano was being cleared out in preparation for the extensive lava flows that were to follow. The cone reached a height of 1,500 feet above the base in the second year, and in the fourth year (1946) it was about 1,700 feet in height.

Lava has been flowing from Parícutin almost continuously since its birth. The first lava began to issue on the second day, and with few exceptions lava has flowed from the volcano every month since that time. The first lava flow emerged from a fissure in the ground some distance from the base of the cone on the north side. Instead of the tarry, or molasses, type of lava, such as is common in Hawaiian volcanoes and in Vesuvius, the lava flow consisted of a mantle of black rubble in which red-hot spots were visible. It was moving 3–10 feet per hour, with an advancing front 750 feet wide and 15 feet thick. It continued to move for several weeks and eventually extended about half a mile from the point of origin. As is true in most volcanoes, lava has rarely flowed from the crater of Parícutin, in fact, only once during the history of Parícutin has lava flowed from the crater, and this was for a period of about two weeks in June 1943 The crater frequently contains lava, but the flows usually emerge from a fissure near the base of the cone. Most, if not all, volcanoes are located along lines of weakness, and the vent develops at some point along the fissure, building up a cone with the accumulation of the ejecta. Although lava may rise in the crater of a volcano, the pressure is usually so great that it breaks

Photo by the author, October 9, 1944

ZAPICHO, THE OFFSPRING OF PARÍCUTIN

THIS SMALL VOLCANO AT THE BASE OF PARÍCUTIN (*see map*) WAS LATER BURIED BY THE LAVA FLOWS OF 1946

out at some point along the fissure before it rises high enough to overflow the crater lip. The point from which the lava actually issues is commonly called the *bócca*, from the Italian word meaning mouth (Spanish, *bōca*). Most of the Parícutin *bóccas* have been near the base of the cone, although in a few cases they have been as much as half a mile distant. All of them have been located either on the northeast or on the southwest side of the cone. This gives rise to the suggestion that the fissure, or zone of weakness, has a northeast-southwest trend.

If a vent develops beneath the edge of the cone, the issuing lava will carry away the overlying section of the cone. This happened in the June 1943 flow, in which a large section of the cone was carried out as surface debris on the advancing lava flow. Masses several hundred feet in height were floated along at the rate of a hundred feet or more per day. These huge "erratics" are preserved today as prominent hills on the surface of the June 1943 flow. In the June 1945 flow, the vent was beneath the cone, but near the southwest edge, and as it developed a triangular section of the cone was pushed out by the pressure of the rising lava. However, after displacing this section of the cone, the lava pushed out along the side of the displaced block, so the mass was not carried away. Considerable explosive activity may occur in connection with the development of a new vent. In October 1943 spectacular fountains of lava, accompanied by intense explosive activity, built up a cone near the northeast edge of the main cone, which in a few weeks attained a height of more than 300 feet, resembling in all respects the main cone. This little volcano was named Zapicho. Shortly, a lava flow began to emerge, and as the flow moved out it carried a wide section of the cone with it. This horseshoe-shaped, or "breached," cone was a familiar landmark at Parícutin until the summer of 1946, when it was finally buried by a succession of lava flows. Such breached cones are a common feature of the landscape in many sections of Mexico.

The cyle of events that culminates in the issuing of a lava flow probably follows a definite sequence, and when all the stages are recognized it should be possible to predict the history of a flow. As a prelude to the development of a *bócca*, the explosive activity of the central crater increases in intensity as lava fills the conduit and rises in the crater. The presence of lava in the crater is indicated by the bombs ejected and by the glow over the cone at night. There is also a correlation between the gas column and the conditions within the crater. The color of the gas column (eruption cloud) gives a clue to its composition. A heavy, black cloud is highly charged with ash particles, whereas a light, yellow column has correspondingly little ash. Not infrequently the gas column will consist almost entirely of steam and will be practically invisible, except in the early morning and late evening, when atmospheric conditions are more favorable for condensation. The explosive activity has little correlation with the gas column; or at least little correlation has been recognized. Frequently, the most violent explosions are associated with little or no gas column. It may be interesting to note, in passing, that when the gas column is highly charged with dust particles, lightning flashes are common; and the sharp, gunshot-like reports of these discharges are familiar phenomena to all who have spent much time at Parícutin. The U. S. Coast and Geodetic Survey operated a seismograph at San Juan de Parangaricutiro for several months in 1945. It was soon observed that some of the most violent explosions, which rattled doors and windows miles from the volcano, were not recorded on the seismograph. This indicates that these explosions were in the gas above the crater. There is a

growing amount of evidence to indicate that many of the explosions in a volcano are the result of the interaction of volcanic gases with the atmosphere, and that these explosions originate in the crater or in the gas above the crater.

RETURNING now to the sequence of events in the development of a *bócca:* the accumulation of pressure as the lava rises toward the surface causes an uplift of the earth's crust. This uplift is indicated by the development of a series of tension cracks, which are prominent features on the ash-covered surfaces. I observed and mapped many of these cracks and in one case (Parícutin flow of September 27, 1944) was able to observe the cracks three weeks before the vent developed. The amount of swelling, or uplift, before the outbreak of the flow is not known, but it must be measured in tens of feet. A similar swelling, measured with tilt meters, has been recognized in Hawaii as an indication of an approaching lava outbreak. The initial outbreak of lava occurs along one of the prominent fractures. The lava usually erupts in a number of places, building up a series of spatter cones until a definite channel is established. The lava then follows the established channel, and the spatter cones become fumaroles. The lava is forced upward in many of the fractures, and, where it fails to reach the surface, dikelike intrusions result. As soon as the outpouring of lava relieves the pressure, the surface sinks, developing a troughlike depression, or graben.

A typical *bócca* has a width of about 50 feet; the pasty lava wells up along the fracture and is squeezed out like a stiff dough. It is accompanied by much gas, and frequently large gas blisters which form on the surface of the lava burst and explode with a sharp report, followed by a hissing noise like air escaping from a tire. In some explosions, fragments of lava are blown to a height of 100 feet, spattering lava for a considerable radius. In the initial outbreak, the debris is carried away on the surface of the lava flow as erratics. In the first few hours the surface of the flow contains an abundance of such debris, usually fragments of earlier flows or portions of the main cone. The lava front advances rapidly in the early stage, and velocities up to 50 feet per minute are not uncommon at the point of emergence. As soon as the lava is exposed to the air a thin, slaglike crust forms.

The rate of flow depends on many factors, such as volume at the vent, viscosity, temperature, gradient of the surface over which the lava is flowing, etc. Velocities up to 30 feet per minute one-fourth mile from the opening, on a normal slope, have been observed, although this is far in excess of the normal rate of flow. The initial lava front is about 15 feet in thickness, and it advances on all downgrade fronts. The flow follows the slope of the ground and will, in time, come to a stream valley, which then determines its course. After the initial stage of rapid movement (feet per minute) the rate of flow decreases to feet per hour, and the thickness increases to about 30 feet. When the forward movement stops or becomes quite slow, lava tongues break out at favorable points along the margin, giving the flow a "distributary-like" pattern. These small flows in turn develop vents which, except in size, have most of the characteristics of the parent (primary) *bócca.* They are 3–5 feet wide, and, as the lava drains from beneath the crust of the flow, the surface subsides and a trough develops over the lava channel. The marginal tongues are usually active for only a day or two, and when they stop the movement of the lava on that margin is completed. The lava coming from these small vents, like the lava from the parent vent, is squeezed out under pressure, and the surface develops a characteristic pattern,

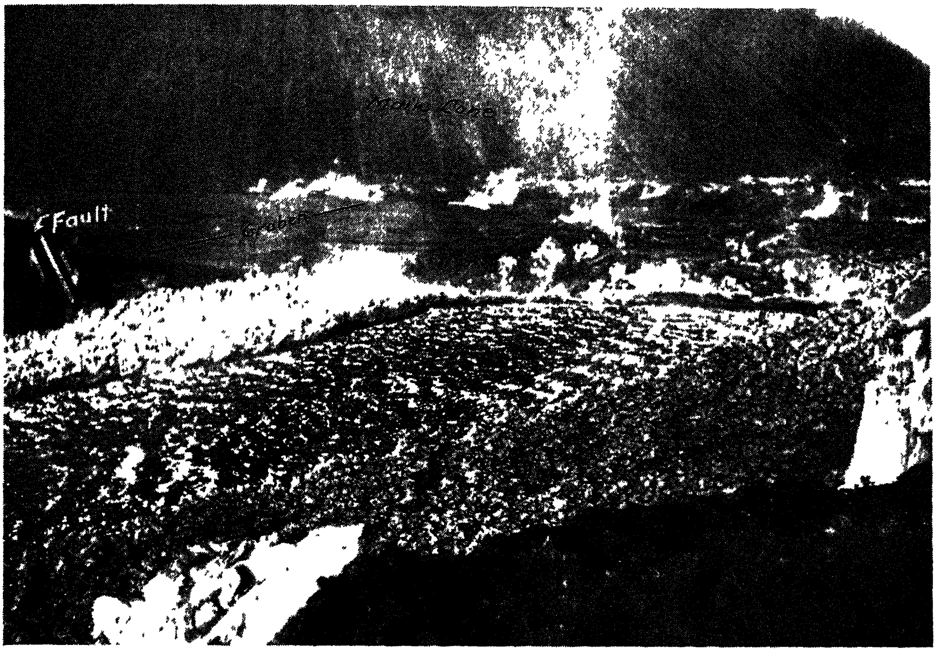


Photo by Tad Nichols, October 19, 1944

THE VENT OF THE PARÍCUTIN FLOW

LAVA IS ISSUING FROM A FAULT MARKING THE WEST SIDE OF A GRABEN. MAIN CONE IN BACKGROUND.

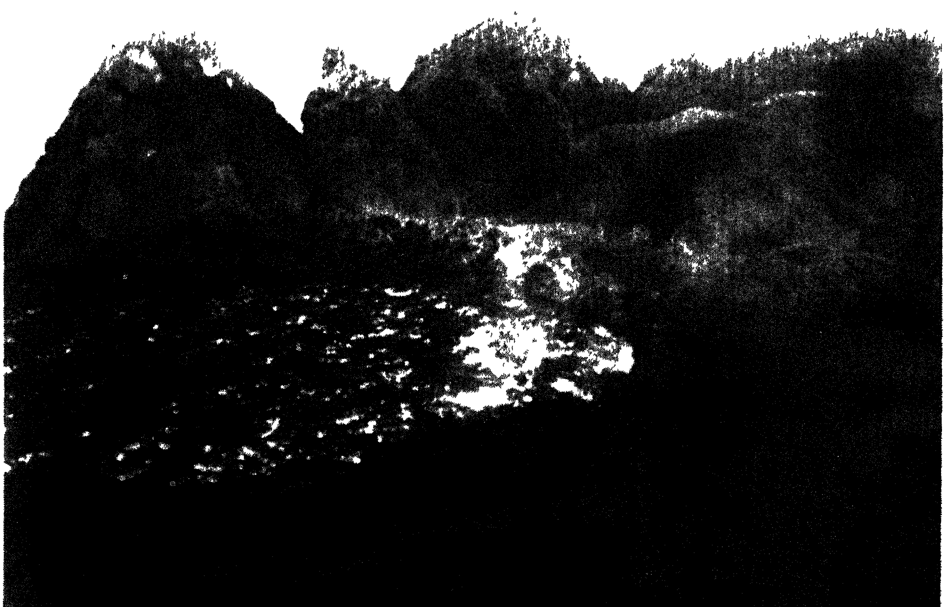


Photo by the author, October 6, 1944

ANOTHER VIEW OF THE ABOVE VENT, OR *BÓCCA*

locally known as "toothpaste" lava. This type of lava is sometimes confused with ropy lava, with which it has no connection.

A lava flow will continue to be active for several weeks, a month to six weeks being typical. However, the San Juan flow, the longest and largest flow to date, began in January 1944 and was active until August 1944, although there were several dormant periods in this interval. This flow, which covered the town of San Juan de Parangaricutiro in June 1944, moved a total distance of about 7 miles.

All the lavas from Parícutin are stiff and viscous, and none of the more fluid, Hawaiian-type lavas is present. The lava seems to lose little of its temperature in the flow. Even the small marginal tongues, which are several miles from the vent and must necessarily have been days or even weeks in reaching their destination, retain approximately their original viscosity. The lava may be compared to a stiff bread dough, or perhaps to taffy candy that is ready to pull. With a long stick I was able to pull the molten material, but it chilled and became brittle the instant it was removed from the flow. Temperature measurements with an optical pyrometer gave readings at several of the vents of 1910°–1935° F. and temperatures at the front of the flow one mile away of 100°–150° F. lower. Microscopically, the Parícutin lavas consist of phenocrysts of olivine in a ground mass composed chiefly of labradorite feldspar.

The characteristics of the lava flows from Parícutin are well illustrated by the Parícutin flow that developed on September 27, 1944, while I was living in a small observation cabin about 1 km. from the south base of the cone. On September 25 and 26 the explosions were quite intense, and at night a brilliant red glow was reflected on the steam column above the crater. Following the explosions the red glow slowly faded, like the lights being turned out in a theatre. This phenomenon, together with the abundance and character of the ejected material, indicated that the crater was filling with lava. Since no lava flow was active at the time, it was expected that a new outbreak was imminent. It was not clear on which side of the cone the vent would develop, since tension cracks were common on both sides along the northeast-southwest trend. The actual outbreak came in the late afternoon of September 27. The first indication was a red glow, observed at sunset near the southwest base of the cone, on the side opposite the observation cabin. The red glow had not been there the night before, and from its brilliance it was apparent that a flow of considerable magnitude had developed. Also, the glow over the crater was gone, indicating drainage of the lava. Upon arriving at the scene the next morning, we found a large graben about 400 feet from the base of the cone. This graben, approximately 1,500 feet wide and 30–40 feet deep, extended in a southwest direction along the fault marking the west side of the graben. Prominent tension cracks had been observed in this area three weeks earlier. The vent—one of the largest to date—was about 75 feet in width, and the lava was issuing at the astonishing rate of 50 feet per minute. In addition, there was a lake of molten lava located in the depressed area about 150 yards to the east of the *bócca*. When the lava lake was first observed from a distance, it appeared to be a whirlpool, but on arriving at the edge of the pool we discovered that the lava was rising from either end of the lake and flowing to the center, where the two streams joined and disappeared in a crevasse. The line of juncture of the two currents shifted from side to side in response to variations in the velocity and volume of the two streams. After disappearing into the crevasse, the lava stream apparently flowed underground and reappeared at the vent described above. There was a large amount of gas in the lava at the so-called whirlpool

Photo by the author, September 6, 1944

OBSERVATION CABIN OF THE INSTITUTO DE GEOLOGÍA

IN THIS *casita*, ALMOST SURROUNDED BY A LAVA FLOW LATE IN AUGUST 1944, THE AUTHOR LIVED FROM AUGUST TO OCTOBER 1944. LIGHT SPOT ON THE LAVA (*lower left*) INDICATES THAT IT WAS STILL HOT.

but comparatively little at the vent, which is further support for the suggestion that the lava lake was feeding the *bócca.*

The lava, flowing westward, carried in its early stage many erratics of the San Juan flow. About one-fourth mile away the lava stream plunged into a ravine about 75 feet deep, and, as it fell over the side, it produced a most spectacular lava cascade more than 300 feet wide at its crest. The flow followed the ravine for nearly a mile, and on emerging on the relatively flat area it spread out as a lakelike mass covering the site of the village of Parícutin, which had escaped (in part) the earlier flows. The rate of advance of the lava when it crossed the main east-west street in the village at 5:00 P. M. on September 29 was 40 feet per hour.

One week later the lava whirlpool had crusted over, and on its surface were many active gas vents, small, chimney-like elevations 3–5 feet high. From the red-hot interior gas was escaping with a roar like the exhaust from a locomotive. Deposits of ferrous chloride and ammonium chloride covered the entire area, and the gas fumes, chiefly chlorine (or hydrochloric acid gas), made it difficult to approach the area except under favorable wind conditions. Some fluorine gas was also present, as evidenced by the fact that I had a camera lens etched by exposure to gas in this area. After covering Parícutin village, the lava entered the valley of a small stream, and on October 17 it joined the San Juan flow. This isolated the observation cabin, leaving it on a lava-surrounded island. Although the flow had cooled for nearly two months, it was still hot, and a crossing could be made only by a route that avoided the hot spots. The crossing selected, which later became

the route for the horse trail, was at the narrowest point of the flow, about 1 km. east of San Juan de Parangaricutiro.

When a lava flow stops its forward motion, a few days or a few weeks may elapse during which the pressure accumulates and another vent develops. This has been the history of the lava flows at Parícutin and is still the pattern of activity. There have been literally dozens of lava flows from Parícutin, all of which have been mapped in more or less detail. The results are somewhat confusing, since many of the flows are, in part, at least, superimposed. Along the north side of the cone, for example, there is fully 400–500 feet of lava, consisting of a succession of superimposed flows, and the end is not in sight since lava was still flowing in this area in September 1946.

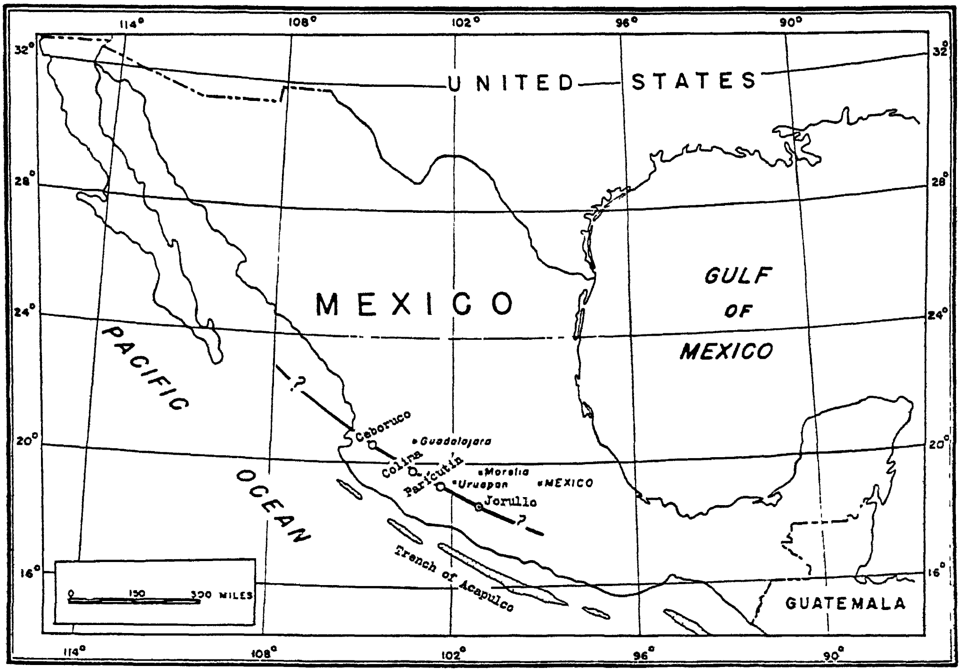
THE source of the heat in a volcano is not known, but the fact that the earth gets hotter with depth is well established by deep borings and by experiences in deep mines. The temperature gradient averages about 1° F. for each 100 feet of depth. If this gradient is constant, it is apparent that a temperature sufficiently high to melt the rocks (2,000° F.) will be encountered at a relatively shallow depth. Whether this heat is residual from a once-molten earth, or is due to radioactivity or other causes, is not known. When a mass of rock melts it expands, for rock, unlike ice, expands on melting and contracts on cooling. At the depth below the earth's surface at which the temperature is high enough to melt the rocks, there is too much pressure to permit expansion; consequently, the rocks cannot liquefy. If, however, the pressure is relieved in some manner, such as the uplifting of the earth's crust in the formation of a mountain range, local reservoirs of magma (lava) may form in those areas where the pressure is reduced. Studies of the earthquakes associated with active volcanoes indicate that they originate at a depth of about 20 miles, which is believed to be the approximate depth of the magma reservoir. Thus, volcanoes are believed to be supplied by local reservoirs of magma existing at a relatively shallow depth beneath the earth's crust.

Granting the existence of this magma reservoir, the next difficulty is to account for the force that causes the magma to rise to the surface. There are several theories; the simplest explanation is that the gases dissolved in the magma force it to rise to the surface, similar to the process resulting in the familiar "oil gusher," in which the gas in the oil is the force bringing the oil to the surface. A more homely example is the eruption of a bottle of soda water owing to the escape of the gas as a result of shaking the bottle. Explaining the origin of the gases is in itself a major problem, but, regardless of the theory accepted for the origin of the magma, some of the constituents will be in a gaseous state. As the magma cools and crystallization on the outer margin concentrates the gases in a smaller and smaller remaining liquid portion, pressure is built up that must in time force an opening to the surface at the weakest point in the roof of the magma chamber. The weakest point will be on a fracture line along which movement of the earth's crust has occurred with the uplifting of the mountain range. The alignment of volcanoes in "trends" is a result of the localization of the vents along these faults. A sinking of sections of the earth's crust in adjacent areas is a common accompaniment of a volcanic eruption. The sinking doubtless compensates for the great volume of material ejected; it also exerts pressure, which may be a contributing factor in causing the magma to rise to the surface.

To appreciate the significance of the location of Parícutin and Jorullo and to better understand their relationship to the other volcanoes of Mexico, a brief

sketch of the geologic and structural history of the region is necessary. The surface features of Mexico are largely related to the geologic history of the region since Cretaceous time. During much of the Cretaceous a broad seaway covered most of Mexico, creating a shallow basin into which was deposited a thick succession of limestones and shales. The uplift of the region at the end of the Cretaceous, in common with the formation of the Rocky Mountains, folded and faulted these sediments, leaving them in a twisted and contorted condition, as may readily be seen in the many roadside cuts along the Pan-American Highway to Mexico City

In Tertiary time this rugged land area was worn down to a low plain, the elevation of which formed the Mexican plateau (Mesa Central), which in its present condition may be described as a great tilted block, the uptilted end along the nineteenth parallel, and the depressed end along the Rio Grande at the northern border of Mexico. The margins of this great plateau are marked by prominent mountain ranges, partly the result of folding and igneous activity, but largely caused by deep dissection of the margins of the elevated block. On the east is the Sierra Madre Oriental, which affords such magnificent scenery along the Pan-American Highway after one leaves Tamazunchale en route to Mexico City. The western margin, marked by the impressive Sierra Madre Occidental Range, separates the Pacific slope from the plateau area of Mexico. Between these two mountainous borders is the great Mesa Central, standing 7,000–8,000 feet above sea level at its southern edge and sloping northward to about 4,000 feet above sea level along the Rio Grande at the northern border of Mexico. The Mesa Central is abruptly chopped off on the south in an east-west line that follows approximately the nine-



THE TRENCH OF ACAPULCO AND ASSOCIATED VOLCANOES
PARALLELING THE TRENCH, VOLCANOES (SHOWN ALONG THE BLACK CURVE) WERE ACTIVE IN HISTORIC TIMES.

teenth parallel and passes near Mexico City. To the south of this line, the structural trend, as revealed in the mountains of the states of Chiapas and Oaxaca, shifts abruptly to an east-west direction, whereas to the north in the plateau section the trend as revealed by the Sierra Madre Oriental and Sierra Madre Occidental is generally north-south. The rocks also change radically to the south of this line, being largely ancient schists and gneisses and other metamorphic rocks, quite unlike the Cretaceous limestones and shales to the north. The folds in the area to the south are related to the structural features of the West Indies and the Caribbean rather than to those of North America.

The great volcanic peaks of Mexico are located along the line that separates the Mesa Central from the area to the south, roughly corresponding to the nineteenth parallel. Beginning on the east, some of the better-known volcanic cones are: Pico de Orizaba (18,701′), the highest peak in Mexico; Popocatepetl (17,887′), the second highest peak in Mexico; Ixtacihuatl (17,342′); Nevado de Toluca (15,020′); and Volcán de Colima (12,661′). Hundreds of other lofty volcanic cones occur along this belt, but the ones listed are the best known.

There were two periods of vulcanism in the Tertiary of Mexico: the first was in the Miocene and affected all Mexico; the second, beginning in the Pliocene, was limited to the east-west line of volcanoes described above. It has been generally assumed by most writers that Parícutin Volcano is related to this same east-west trend. Its location, although near the Pacific Ocean, is in this belt. The only volcanoes in Mexico that have had eruptions of more than fumarolic character in historic times are Colima, Jorullo, Ceburoco, and Parícutin, all located along the western end of this so-called trend and near the Pacific Ocean.

A deep trough in the Pacific Ocean, a short distance offshore and parallel to the Mexican and Central American coast, has been known for a number of years. Recent studies show that this trough consists of two parts: the northern part, called the Fosa de Mexico (the deepest portion is designated as the Trench of Acapulco), is adjacent to the section of Mexico in which the active volcanoes are located; the southern part, off the Guatemala–Salvador coast where other active volcanoes occur, is known as the Trench of Guatemala. It is of interest to note that similar troughs are also present off the Alaskan coast, adjacent to the active volcanoes of the Aleutians, as well as off the coast of Japan and elsewhere around the Pacific margin where active volcanoes are found. Furthermore, the trough area off the Pacific coast of Mexico is the center of many earthquakes, indicating that it is still an active zone. The evidence strongly suggests that Parícutin is related to a trend parallel to the Pacific Ocean, and that its alignment with the older, now-inactive, volcanoes of the east-west trend in Mexico is a coincidence. Hobbs has recently supported this idea and further contends that Parícutin Volcano is related to a new mountain range now rising along the Pacific coast.

A question frequently asked is, How long will Parícutin continue to be active? Certainly no one is able to answer this question with any degree of assurance, but certain information is available that may bear on the matter. Since volcanoes continue to grow as long as they are active, size is a measure of age. The age of such lofty peaks as Popocatepetl must be measured in tens of thousands of years; that of the small cinder cone of Jorullo, in a few months. Because Jorullo is in the same area and similar in character, it was reasonable to expect that Parícutin would follow the same pattern. Parícutin has already surpassed Jorullo in length of life, size, and volume of lava extruded, although we have

no reason to believe that it will continue to be active indefinitely. The magma reservoir beneath Parícutin may well be the same reservoir that Jorullo tapped (or for which Jorullo served as a safety valve) nearly 200 years ago. When the gas pressure in the reservoir is reduced, Parícutin will cease activity; and when the next outbreak occurs some 200 years from now (if the same pattern is followed), the vent may be another cornfield many miles from the present one. With careful study and constant observation and with the equipment now available, scientists should be able to predict not only the approximate time but the exact spot of the next eruption.

NEW ENGLAND STONES

By Winifred Duncan

Big as bare breasts they round up through the moss;
Breasts of a giantess, grey and rough with time.
Veining them, lichen and vine
Make a design.

Always the ground slopes downward from their curves
Down to the hollows where the cedars stand
Black in the sun, where the white birches run,
Hand in hand.

These are the hollows that the glacier made
Back in the dark days when the earth was young.
With a cold lip, licking and rounding stones
To make her bones.

Down the long hills her rivers ran like arms,
Carving the mountains, scraping flat the marsh.
Now all is wreathed in mist of leaf and flower;
Nothing is harsh.

On her round shoulders, on her curving thigh
The poet dreams; ants run; the spider-race
Spins delicate webs, and the fly
Washes his face.

Illusion of safety! So soon have we forgot
The past of mother earth? We suck and ravage
A creature made of cataclysms savage!
She is grown old, and close the great stars swing
To blast us from these tired breasts
Where frantically we cling.

HITCHING OUR COUNTRY TO THE STARS

By REAR ADMIRAL LEO OTIS COLBERT

Having devoted his entire professional career to the U. S. Coast and Geodetic Survey, Admiral Colbert (Sc.D, Tufts) knows whereof he writes. He has been navigator and executive and commanding officer of Survey ships in the coastal waters of the United States, Alaska, and the Philippines. During World War I he served as Lieutenant Commander on the U.S.S. Northern Pacific, *a troop transport. In 1931 he was engaged in a comprehensive hydrographic survey of Georges Bank, utilizing advanced methods of offshore surveying. Since 1938 Admiral Colbert has been Director of the Coast and Geodetic Survey.*

WHERE in the world are we? How deep is the ocean? How high is high water? Finding the answers to these questions has been the job of the Coast and Geodetic Survey during more than a century of surveying and charting our coastal waters, and of establishing geodetic control in the interior of our country. The close relationship that exists between surveys and charts and the stars and planets is perhaps not generally known; yet astronomy is at the very foundation of all surveying operations that deal with extensive areas and that require an accurate orientation on the surface of the earth. Astronomy is the medium by which we hitch our planet to the stars and to the other planets. The engineer, the surveyor, the navigator—who deal with practical astronomy—all owe a debt to the theoretical astronomer, whose determinations of the motions of the heavenly bodies and whose formulation of tables expressing their projected positions on the celestial sphere furnish data for use in establishing position on the surface of the earth—be it of an engineering structure on land, a lighthouse on the coast, or a vessel at sea.

ASTRONOMY AND THE COAST SURVEY

It is an interesting fact that at the time of the inception of the Coast Survey in 1807, there was not a single working observatory in the country for the training of astronomers, and there was not a college in the United States that included a course in geodetic surveying in its curriculum. This is but one example of the magnitude of the task that faced Professor Ferdinand R. Hassler when he accepted the commission from President Jefferson to direct the survey of our coast.

One of Hassler's first hurdles involved astronomy. Being a man of outstanding scientific attainments, Hassler planned a survey along lines of lasting worth and proved value. There were many in those days who saw no need for elaborate base measurements and triangulation systems and who advocated that the surveys of

FERDINAND R. HASSLER
FIRST SUPERINTENDENT OF THE COAST SURVEY

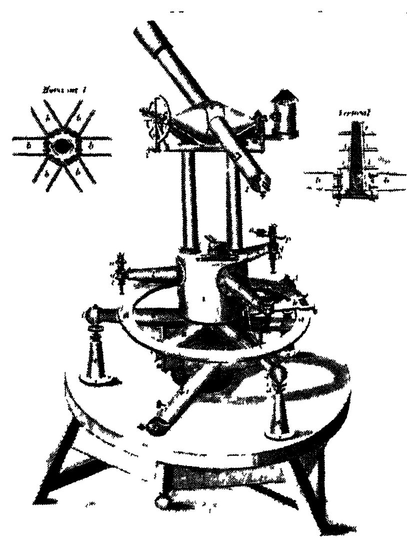
our coast be controlled by astronomic determinations alone. Hassler understood clearly that accurate surveys of extensive areas could only be accomplished by the geodetic process, which is, properly, a combination of the astronomic and the geodetic. Fortunately, Hassler's scientific approach prevailed, and the plan he proposed became the model for our work.

Some of Hassler's contemporary workers and a number of those who followed him were among the foremost astronomers in the country, and their contributions, in both methods and equipment, to the development of practical astronomy are indelibly engraved in the records of Coast Survey achievements.

In 1834 Captain Andrew Talcott, of the Corps of Engineers, discovered the differential method for the determination of astronomic latitude with the zenith telescope. Through its adoption and refinement by the Coast Survey, the Talcott method received great impetus toward world-wide use. The accuracy of the results obtained by this method is superior to that of every other field method and compares favorably with the results obtained with the largest observatory instruments.

The application of the Talcott method for determining latitude indicated some radical errors in the published star places. The various observatories of the country immediately undertook the necessary additional observations to furnish more accurate star places; so that one of the by-products of the method was an improvement in the star catalogue.

In the early history of the Coast Survey, the determination of astronomic longitude was one of the important problems that required solution. In those early days longitude was determined by observing certain celestial phenomena, such as the eclipses of Jupiter's satellites and the occultations of stars by the moon, which occurred everywhere at the same instant



ZENITH TELESCOPE
FOR DETERMINING ASTRONOMIC LATITUDES.

of time. The most practical method, and the one which gave the best results, was the use of highly accurate timepieces known as chronometers. A number of these were used to compare the difference in time between the two places where the observations were being made for difference of longitude. To minimize any error in rate, the chronometers were transported back and forth between the stations.

Within a few months after Morse flashed his first telegraphic message over the wires between Baltimore and Washington, Professor Bache, who succeeded Hassler as head of the Coast Survey, began experiments for an application of the telegraph to longitude determinations. On October 10, 1846, the telegraphic method was put into successful operation, and time signals were exchanged between Washington and Philadelphia.

The determination of longitudes by this method was extended to other parts of the country as rapidly as the electric telegraph came into practical use. Although this established a coordinated network of these accurately located points, it still

left the longitude relationship of America with the prime meridian through Greenwich, England, dependent upon chronometric determinations.

Between 1849 and 1855 the Coast Survey instituted expeditions to exchange chronometers between Cambridge, Mass., and Liverpool, England. In the last year six voyages were made, three in each direction, and fifty chronometers were transported.

Upon the completion of the first successful Atlantic cable in 1866, the Coast Survey, under the direction of Dr. Benjamin Gould, the noted astronomer, organized a project making use of the cable to measure the difference of longitude between Greenwich and the Naval Observatory at Washington. The results proved that the chronometric determination of 1855 was in error by over a second of time, or about .25 mile.

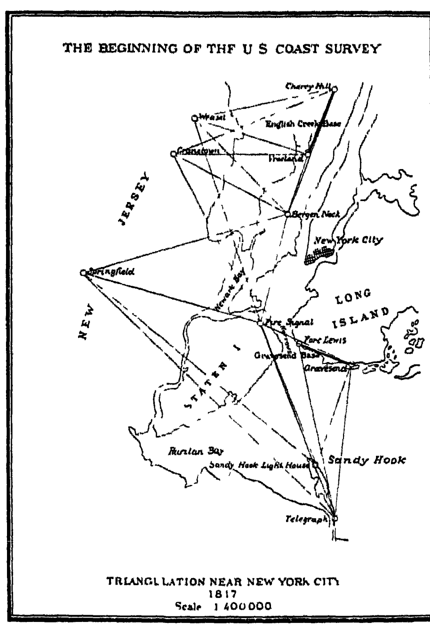
The perfection of the methods used in the United States for determining latitude and longitude placed this country well in the forefront of astronomic achievement. It was freely stated at the time that geographical values of the positions of the principal astronomic stations of the Coast Survey were determined with greater accuracy than the values known for any European observatory.

The introduction of the radio method of determining longitude in 1922 did not increase the accuracy of the results, but merely made the determination more convenient and more economical.

In recent years, important contributions to practical astronomy have been made by international cooperation in which the Coast and Geodetic Survey has participated. One of these has been the establishment of a world longitude net for the coordination of longitude work throughout the world; another, the establishment of variation of latitude observatories at five places around the world on approximately the same parallel of latitude. In this country these observatories are at Gaithersburg, Md., and Ukiah, Calif. The results furnish information for the study of the wanderings of the geographical pole.

TRIANGULATION

When the geodetic surveyor has located a survey point on the surface of the earth from astronomic observations, he has established a starting point for his land operations. The next step is to determine the direction to a second station by an observation on Polaris or other celestial body for azimuth. The third is to make an accurate measurement of the distance between the two stations. These provide the foundation for a method of locating other points on the surface of the earth without making direct measurements. This method is known as triangulation. It is the only feasible method of measuring great distances with a high degree of accuracy, independent of the character of the intervening terrain.

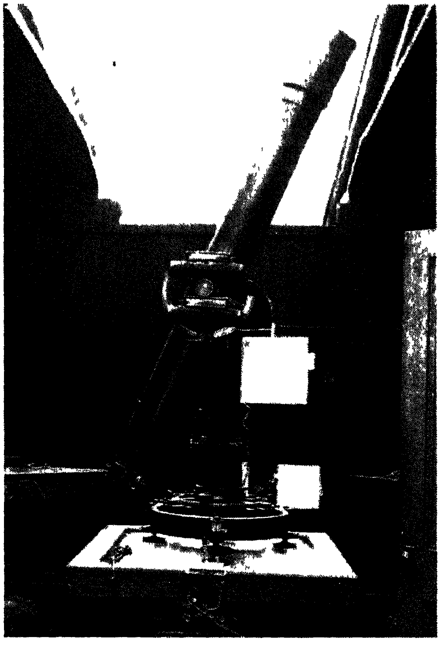


FIRST COAST SURVEY

FROM AN ACCURATELY MEASURED BASE LINE (SHOWN BY HEAVY LINES) AND THE MEASURED ANGLES OF A SERIES OF CONNECTED TRIANGLES, THE LENGTHS OF THE OTHER LINES ARE DETERMINED.

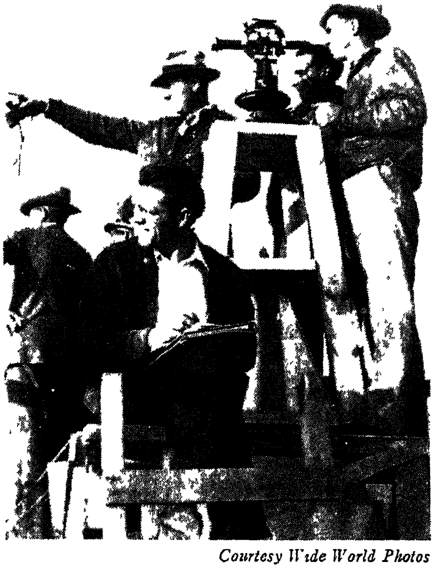
The earliest triangulation work in the United States was executed in 1817 in the vicinity of New York City. It was here that Professor Hassler made his first astronomic observations. In his report Hassler says: "A special station was made upon Weasel Mountain for latitude and azimuth, and a solar eclipse occurring just at the same time gave occasion for an observation of longitude at the same place."

Since this early triangulation, an elaborate network has been extended over the entire country, and tens of thousands of control points have been established. These are permanently monumented with markers for use as starting points in surveys for topographic, geologic, and other forms of mapping, and for every engineering project requiring an accurate knowledge of the horizontal relationship between points on the earth's surface.



24-INCH THEODOLITE

THIS INSTRUMENT USED BY PROFESSOR HASSLER IN THE EARLY TRIANGULATION REQUIRED A SPECIAL HORSE-DRAWN CARRIAGE TO TRANSPORT IT FROM ONE STATION TO ANOTHER. THE STREAMLINED THEODOLITES OF TODAY CAN BE CARRIED BY ONE MAN.



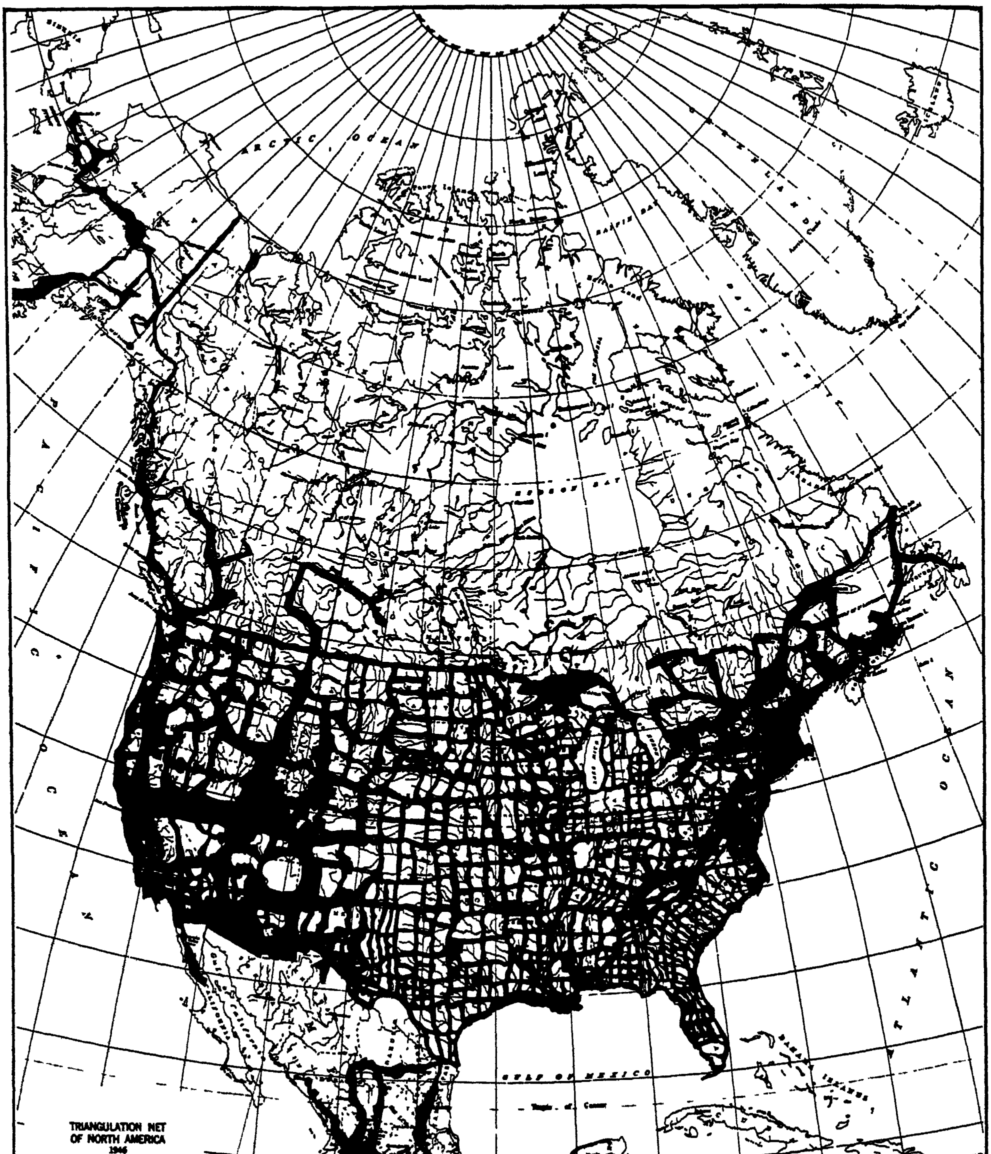
Courtesy Wide World Photos

TOP OF THE MONUMENT

TRIANGULATION PARTY MAKING OBSERVATIONS FROM THE TOP OF THE WASHINGTON MONUMENT, WASHINGTON, D. C (555 FEET HIGH), IN ORDER TO FIX ITS POSITION IN LATITUDE AND LONGITUDE NOTE THE COMPACTNESS OF THE MODERN THEODOLITE AS CONTRASTED WITH THE ONE USED BY HASSLER.

The shape and size of the earth must be taken into account in the survey of a country as large as the United States; otherwise, serious errors will be introduced in the results. To determine curvature, astronomy again enters the picture.

From many precise measurements involving astronomic observations and triangulation, the earth has been found to approximate closely the mathematical figure known as the oblate spheroid, with a polar diameter about 27 statute miles less than its equatorial diameter; hence, a spheroid of reference has been adopted for correctly placing the network of triangulation. The adopted reference spheroid deviates from the true figure, and this deviation is greatest in the vicinity of the high mountain ranges and the great ocean deeps. It is because of these deviations that position determination by astronomic observations alone is unsatisfactory. Many cases are on



TRIANGULATION NET OF NORTH AMERICA

THE DOMINION OF CANADA AND THE REPUBLIC OF MEXICO ARE CONNECTED BY TRIANGULATION TO THE UNITED STATES AND ALASKA TO FORM ONE OF THE LARGEST CONTINUOUS ARCS IN THE WORLD.

record of such deviations, one of the most pronounced being on the island of Puerto Rico, where a high mountain range runs east and west the length of the island, with the deep waters of the Atlantic to the north and the Caribbean to the south. Astronomic stations had originally been established on the north and south coasts of the island. When these were connected by triangulation, the true distance between them was found to be about 1 mile less than that given by the astronomic determinations.

In any engineering or scientific undertaking involving a large area, it is important that a full coordination and correlation be secured of the surveys, maps, and charts affected. A hydrographic or topographic feature on the earth can have but one latitude and longitude, which must be the same on every map or chart on which it appears. This can only be accomplished through the adoption of a single horizontal datum for the triangulation points in the country.

In the United States the origin for all Federal mapping is station Meades Ranch in central Kansas. Its latitude and longitude on the reference spheroid were fixed by a mathematical adjustment based on a study of numerous astronomic stations throughout the country that had been connected by a continuous system of triangulation.

Station Meades Ranch was selected because it was near the geographical center of the United States and because it was at the junction of two great arcs of triangulation, one along the thirty-ninth parallel and the other along the ninety-eighth meridian.

Today the continent of North America, from the lower end of Mexico through the United States, Canada, and Alaska to Bering Strait, is coordinated on this single datum. In this network is contained the longest arc of continuous triangulation in the world.

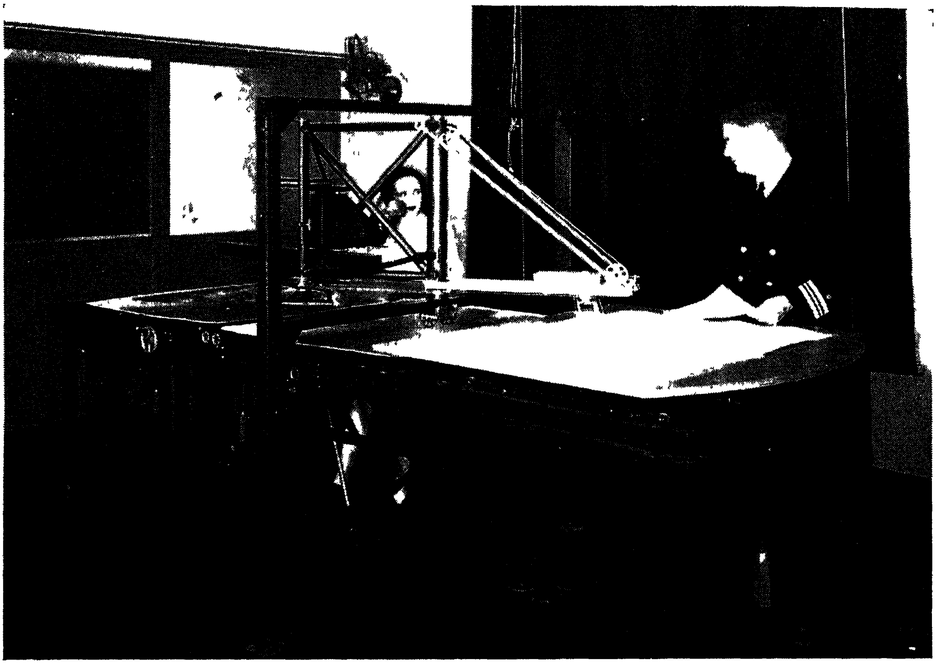
ORIGIN FOR U. S MAPPING

STATION MEADES RANCH IN CENTRAL KANSAS IS THE ORIGIN OF THE NORTH AMERICAN DATUM OF 1927, TO WHICH ALL FEDERAL MAPPING IS TIED. MANY THOUSANDS OF CONTROL POINTS, PERMANENTLY MARKED WITH BRONZE DISCS SET IN CONCRETE, FURNISH STARTING POINTS FOR LOCAL SURVEYS AND ENGINEERING CONSTRUCTION.

The control points that the geodetic engineer has established along the coasts and in the interior of the country are used by the topographic engineer as the framework for his map. The details he fills in with the plane table or by the more modern method of aerial topography. Photographs taken from the air are reduced to map form by means of specially designed stereoscopic plotting instruments.

MAPPING THE OCEAN FLOOR

Just as without astronomy our land surveys could not be properly positioned on the surface of the earth, so it is with surveys of the water areas. The same fundamental problem is involved, although there is a difference in the methods and instruments used. When the navigator leaves the shores of one country and sets out for the ports of another, he has nothing to guide him over the trackless sea except the stars and his chart. Whether he de-



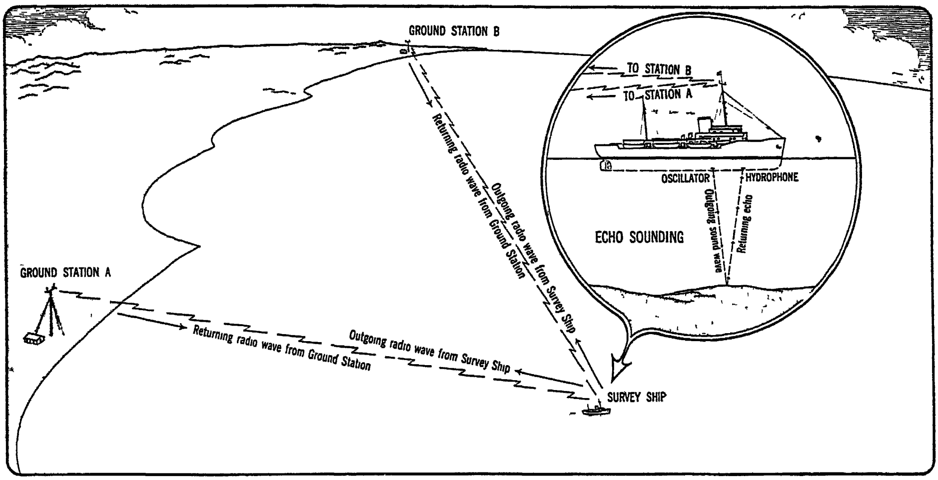
9-LENS STEREOCARTOGRAPH

DESIGNED IN THE COAST AND GEODETIC SURVEY FOR STEREOSCOPIC PLOTTING OF TOPOGRAPHIC MAPS FROM 9-LENS AERIAL PHOTOGRAPHS.

termines his position at sea by observations on terrestrial objects or celestial bodies, or by electronic methods, he must have a chart on which he can properly relate that position to the land area and to the surrounding submarine features. The foundation for the nautical chart must therefore be hydrographic surveys that are tied into the same system of spherical coordinates as is used in establishing control points on land and in delineating the topographic features.

Hydrographic surveying involves a measurement of depth and a determination of position. The revolutionary advances made in this field during the past two decades have had a profound effect on the usefulness of the nautical chart. The measurement of depths by hand lead and wire has given way to measurement by sound—better known as echo sounding. In this method depths are registered automatically on a graduated dial and can be read with equal facility whether measuring a depth of 2 or 2,000 fathoms of water. Graphic recorders are rapid and sensitive enough to detect and record wrecked ships lying on the ocean floor.

Determination of a depth has little value unless the latitude and longitude are known, so that the depth can be shown on the field survey sheet or on the published chart. When in sight of land the position of the survey vessel is determined by means of the well-known three-point fix method from sextant angles taken on board ship to objects on shore previously correlated with the coastal control net. Beyond the limit of visibility of shore objects, underwater sound ranging has been used. By exploding a bomb in the water near the survey vessel, measuring the time of arrival of the sound impulse at two or more previously located hydrophone stations, and employing the knowledge of the velocity of sound in sea water, the distance to the



ECHO SOUNDING AND ELECTRONIC POSITION DETERMINATION

WHILE THE SHIP'S FATHOMETER MEASURES THE DEPTHS UNDER THE VESSEL BY SOUND, THE POSITION OF THE VESSEL IS DETERMINED BY ELECTRONIC METHODS.

vessel can be determined. Used in conjunction with this method is the taut-wire sun-azimuth traverse. The distances between buoys are measured by means of a taut-wire apparatus, and the azimuths or bearings are determined from observations on the sun.

Occasionally it is desirable to begin a hydrographic survey at the offshore end and work in toward shore. Such was the case with the Georges Bank Survey begun in 1930. Georges Bank is an important area to both the fishing and the shipping industries. In order to modernize the charts of the Bank as early as possible, it was desirable to begin the survey near the offshore end of the Bank, about 200 miles from Cape Cod, where the westbound shipping lanes cross the continental shelf. The basic position for the project—which comprised an area of about 28,000 square miles—had therefore to be an astronomic one.

A buoy was anchored near the outer edge of the Bank and its position determined by a long series of star observations from the surveying vessel anchored nearby. Eighteen sets of sights were made by three observers on eight days, each set consisting of four or more stars. The position obtained was held fixed for the entire survey, which covered a period of three working seasons. From it, additional control buoys were established by acoustic methods and by sun azimuths. When the connection was made with the coastal triangulation, the error in the system was found to be less than .25 mile—a result far better than was expected when the survey was begun.

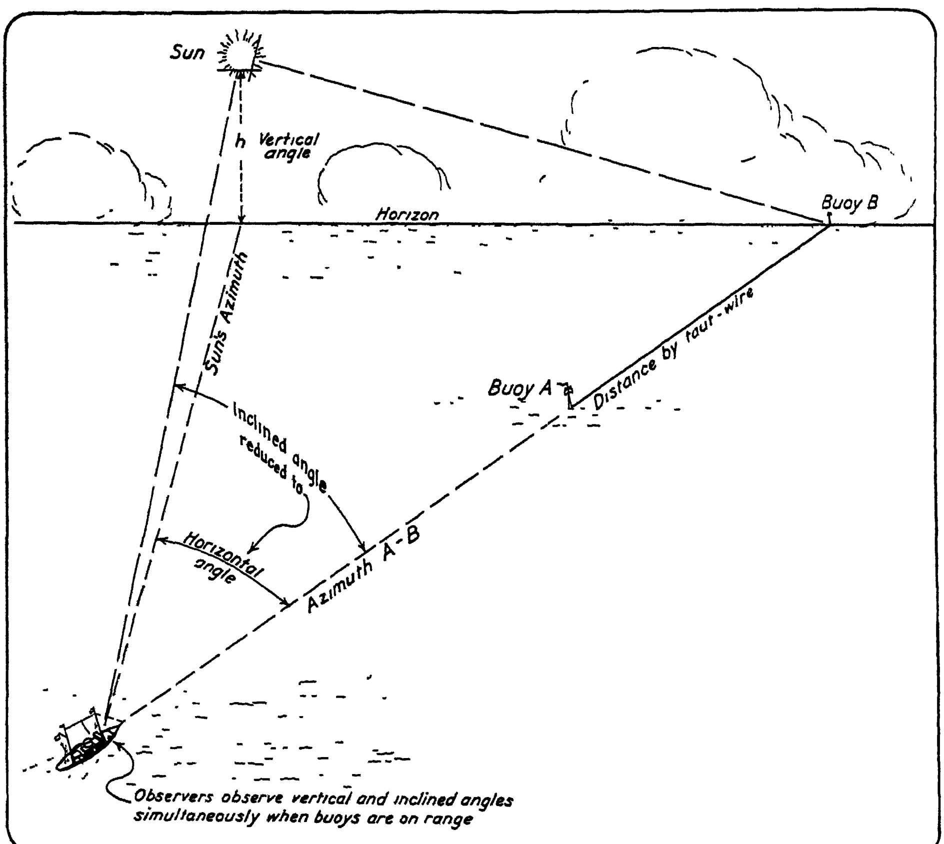
Astronomic sights are used in hydrographic surveying in the same manner as in navigation, except that they are taken with greater precision and care. An observed altitude on a heavenly body determines a circle of position on which the observer is located. Observations made on two or more stars suitably spaced around the horizon define circles of position, the intersection of which determines the position of the observer.

Acoustic methods of surveying have steadily pushed seaward the frontiers of accurate hydrographic surveys and have been used to explore the intricate patterns of our deep coastal slopes. These methods are responsible for the discovery of many

new and amazing facts about the continental shelf, the seaward extension of the land mass. The continental shelf is not of uniform width. Off certain portions of the Pacific Coast and Alaska it is quite narrow, whereas along the Atlantic Coast it varies from 10 miles in the vicinity of Palm Beach, Fla., to about 200 miles off Cape Cod, Mass. In general the 600-foot depth line is considered to be the edge of the shelf. From here the submerged land drops abruptly to ocean depths.

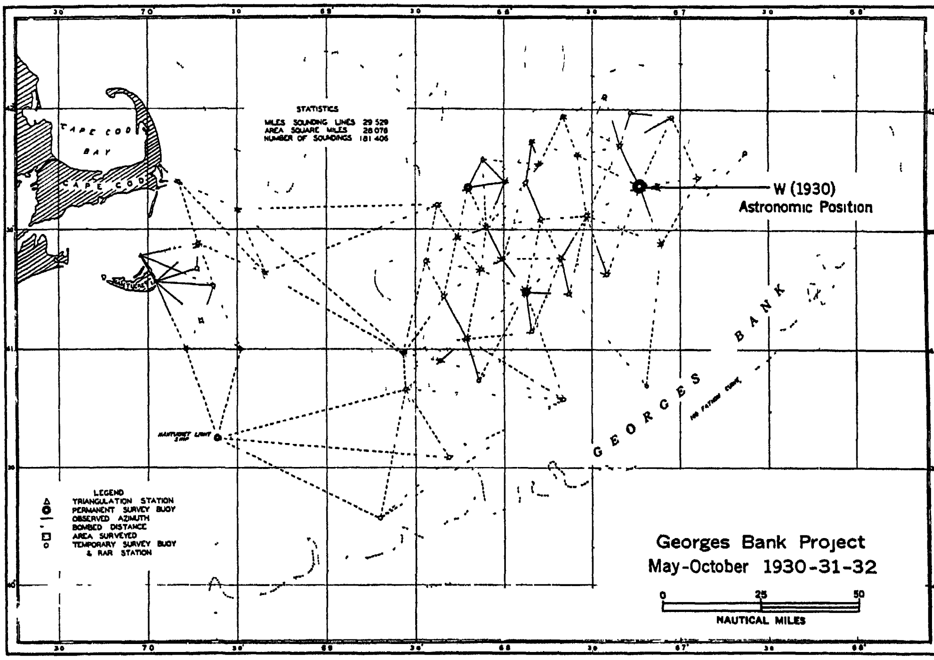
On September 28, 1945, a Presidential proclamation extended the jurisdiction and control of the United States over the natural resources of the subsoil and sea bed of the continental shelf. This added approximately 300,000 square statute miles to our jurisdiction in continental United States and about 550,000 square statute miles in Alaska.

Modern hydrographic surveys covering the area of the shelf have modified radically our former belief that the ocean floor is a flat, monotonous plain, devoid of rugged relief. How erroneous this concept was has been amply demonstrated by the many basins and ridges, troughs and peaks, that have been discovered since the advent of the new hydrographic methods. Submarine topograhy has been found in many areas comparable in extent and magnitude



TAUT-WIRE SUN-AZIMUTH TRAVERSE

IN SURVEYING OFFSHORE, DISTANCES BETWEEN CONTROL BUOYS ARE SOMETIMES MEASURED BY WIRE, AND BEARINGS ARE DETERMINED FROM OBSERVATIONS ON THE SUN.



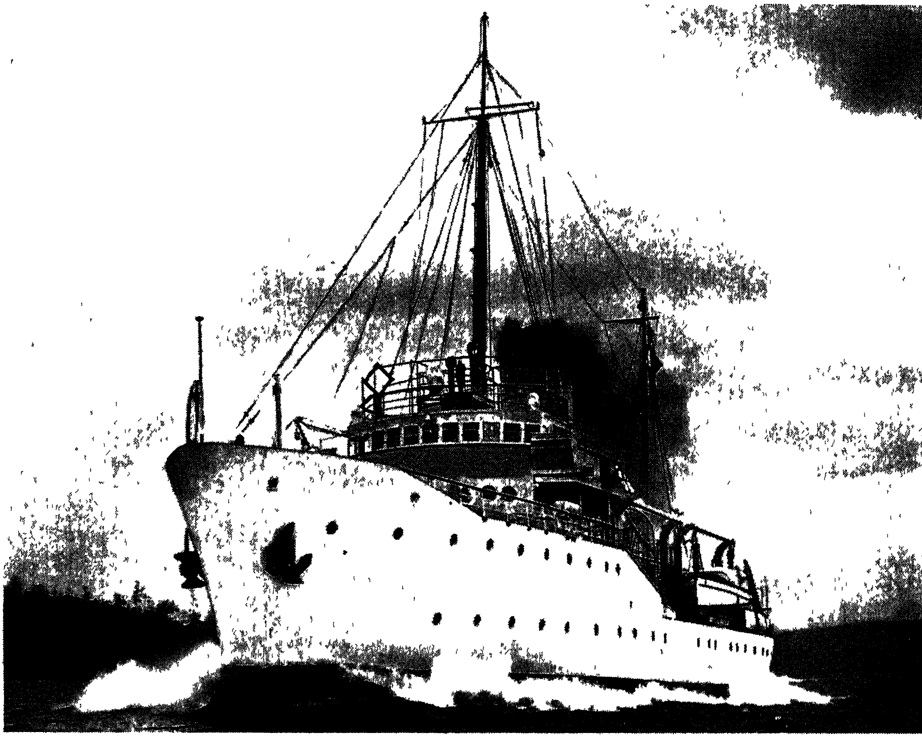
BUOY CONTROL SCHEME FOR SURVEY OF GEORGES BANK

A LONG SERIES OF STAR OBSERVATIONS FIXED THE POSITION OF BUOY "W" FROM WHICH THE CONTROL WAS EXPANDED TO A CONNECTION WITH SHORE STATIONS.

to some of the major topographic formations that exist on land. The continental shelf—particularly along the northeast Atlantic Coast—is indented by many submarine canyons, penetrating many miles into the shelf. One of the most pronounced of these, and perhaps one of the greatest in the world, is the one that, lying 120 miles southeast of New York Harbor, marks the submerged gorge of the ancient Hudson River. If this canyon could be stripped of its blanket of ocean, we could in some places see across it; the floor of the canyon would lie some 3,600 feet below. The mouth of this canyon has been traced to depths of 6,000 feet below sea level. The Hudson Canyon had been known to geologists for some years, but its true form and size were not known until modern methods of hydrographic surveying were used in 1936.

In the Gulf of Mexico, in the vicinity of the delta of the Mississippi River, a large depression, or submarine trough, has been found that penetrates the otherwise flat and smooth continental shelf for a distance of about 20 miles. To the northeast of this trough is a small dome-shaped hill which, geologists believe, is a salt-dome uplift. It stands about 160 feet above the sea floor and rises to within 200 feet of the water surface. In shape this dome has been found to resemble closely some of the buried salt domes along the coastal plains of Louisiana and Texas where many of our oil reserves are located. Numerous other, similar formations have been found along the edge of the shelf here, 100 and more miles from shore.

Off the coast of California, about 50 miles southwest of San Francisco, a huge submerged mountain has been found, rising 4,000–8,000 feet above the ocean bed and to within 2,500 feet of the sea surface. Other, similar seamounts, some more and some less pronounced, abound along the Pacific Coast and in the Gulf of Alaska.



U. S. COAST AND GEODETIC SURVEY SHIP *EXPLORER*

ONE OF THE LATEST ADDITIONS TO THE FLEET OF SURVEY VESSELS USED TO EXPLORE THE HIDDEN MYSTERIES OF THE DEEP, THE SHIP CONTAINS THE LATEST IN SURVEYING EQUIPMENT.

TIDE PREDICTING MACHINE

THIS ROBOT PREDICTS THE TIMES AND HEIGHTS OF THE TIDE FOR ANY TIME IN THE FUTURE.

An unusual and interesting submarine feature along the northern California coast is the Mendocino Escarpment, a clifflike formation, 6,000 feet high on the northern face, that juts into the Pacific for 66 miles, almost at right angles to the general trend of the coast line. This remarkable feature is on the seaward extension of the famous San Andreas Fault, which extends throughout the length of California. The San Francisco earthquake of 1906 was due to earth movement in the vicinity of this fault.

In the Gulf of Alaska, extending from Yakutat Bay and paralleling the Kenai and Alaska peninsulas and the Aleutian Archipelago, there is the remarkable Aleutian Trench. This elongated depression is traceable for a distance of 2,200 statute miles, the last 1,400 of which conform to the

arc of a circle of a radius of 760 statute miles. The floor of the Trench stands at its maximum about 25,000 feet below the surface of the sea and about 9,600 feet below the adjacent floor of the Pacific Ocean south of Attu Island. It was along the steep slopes of this Trench that seismograph records fixed the epicenter of the seaquake of April 1, 1946, which gave rise to such pronounced sea waves in the Hawaiian Islands and along the California coast.

In the Philippine Islands, just east of Mindanao, is the impressive Mindanao Deep, where the greatest known ocean depth—35,400 feet, or slightly over 6.5 miles—was obtained with an echo sounder. If we could put Mount Everest into this great ocean deep, the world's highest peak would still be covered by a mile of sea water.

Recently, electronic methods have been developed by the Coast and Geodetic Survey for use in hydrographic surveying. These will permit accurate surveys to be extended greater distances offshore than heretofore. Shoran equipment—a form of radar used during the war for precision bombing—has been adapted to, and successfully used for, position determination in the western Aleutians and off the coast of Maine. By this method a survey ship at distances of 50–100 miles offshore can be located with an accuracy comparable to that of a three-point visual fix on shore objects.

Another electronic device is being developed by which control of comparable accuracy with shoran will extend the offshore limit of accurate hydrographic surveys to as far as 300 miles. This may open up new fields for scientific research in an area that many believe to be a future reservoir of natural resources. Hitherto, one of the great drawbacks to such investigations has been the limitations in the methods of offshore surveying; even with the most nearly perfect geophysical methods there must still be a correlation with certain aspects of hydrographic surveying in order that a reliable topographic picture can be obtained of the area under investigation.

TIDAL PHENOMENA AND PREDICTION

Our country is coupled to the heavenly bodies in still another way. We are all familiar with the rhythmic rise and fall of the sea. This alternate elevation and depression—which at most places occurs daily and which we call the tide—can be expressed graphically in the form of a mathematical curve in which height and time are the two factors.

The Coast and Geodetic Survey is interested in tidal phenomena for two reasons. In its hydrographic work, the height of the tide must be known every instant during which a survey is in progress in order that depths obtained may be corrected and referred to a common datum plane for publication on the nautical chart. Tidal observations are also necessary in connection with the publication of tide tables, which furnish the navigator predicted times and heights of the tide at the important ports of the world.

The connection between the tide and the sun and moon was recognized at a very early period, but it was not until Sir Isaac Newton formulated his theory of the law of gravitation, during the seventeenth century, that a rational explanation of tidal phenomena was advanced. Newton proved that the tides were a necessary consequence of the law of gravitation; hence, the attractive forces of sun and moon on the earth and the waters overlying it are the principal tide-producing forces. The moon being nearer, its tide-producing force is more than twice that of the sun.

If we examine the tide curve for a period of a month, we find that the times of high

and low water of one day occur 50 minutes later than those of the preceding day. This period is characteristic of the tide practically everywhere and is irrespective of the range or type of tide found. The moon in its revolution around the earth shows the same retardation of 50 minutes.

The height of the tide during a month is affected by the relative positions of sun, moon, and earth. At times of new and full moon—when sun, moon, and earth are in line—the tides have their greatest rise and fall; whereas during first and third quarters, the rise and fall are at a minimum.

Tides differ in the character of the rise and fall. At New York, for example, there is the semidaily type of tide (two tides of approximately equal range); at Pensacola, there is the daily type (one tide a day); and at San Francisco there is the mixed type of tide (two tides with unequal range).

The tide varies in range from place to place. At the Atlantic entrance to the Panama Canal it is less than a foot in 6 hours, whereas at the Pacific entrance, only 30 miles away, it averages 12.5 feet. At Anchorage, Alaska, the rise and fall is approximately 33 feet.

Since the tide-generating forces are of astronomic origin, it might be supposed that the tide would exhibit similar characteristics everywhere. This would be the case if there were no other influences. Actually, the tides as they occur in nature are the result of the varying responses of the different ocean basins to the tide-producing forces, as modified by local terrestrial features. This theory of the tides that makes them local phenomena, rather than a single world phenomenon, was developed in the latter part of the nineteenth century by R. A. Harris, a tidal mathematician in the Coast and Geodetic Survey. In predicting tides for any port, it is necessary first to secure tidal observations for about a year. After that predictions can be made for any future time. Tide prediction is a complicated mathematical process, but the work has been greatly simplified by the use of the Tide Predicting Machine, designed in the Coast Survey. Astronomical equations involving as many as thirty-seven factors are solved mechanically, to produce the tide in nature.

THUS, we see that astronomy is at the foundation of all our survey operations: By means of triangulation we have tied together astronomic observations made throughout the country. This has made possible the determination of the figure of the earth and the best placement of our country on that figure. We have tied into the network of triangulation our mountains, rivers, coast lines, and other land features; and by extending our control network offshore we have tied in our waters, our continental shelves, and the ocean features beyond. In short, we have hitched our country to the stars.

PUTTING KNOWLEDGE TO WORK

By DONALD WASSON

After his graduation from Oberlin in 1935 Mr. Wasson attended the University of Genoa as an exchange student. In 1937 he received the degree of B.L.S. from Columbia University School of Library Service. In March 1941 he entered the Army as a private, emerging as a captain nearly five years later. He went immediately to his present post as Assistant Librarian, Council on Foreign Relations, New York City.

FOREIGN visitors to this country are often reported to be amazed by American facilities for research. It is gratifying that they should be so unconditionally enthusiastic about some of the institutions that most of us take for granted, but a librarian reading about their reactions wonders if they also have been shown the great wealth of library resources and facilities without which our research institutions could not function to maximum constructive capacity.

A visitor's possible lack of information would be excusable since, rich as we are in book resources and organized research collections, many of us accept our libraries as a matter of course; or we think only of the public or the university library. Comparatively few people realize that among the libraries of the United States there is a great class called "special libraries," the veritable heart of all research activity and research institutions. It is our purpose here to call attention to this group of libraries; to point out the major part they play in the modern research world; and to apprise the reader who normally depends on his library for recreational reading only—or at most for verification of simple facts such as weights, conversion factors, or figures on population—of the assistance special libraries can give.

Before describing some of the actual services and materials offered by these special collections, it may be well to define a special library and show how it differs from the general public or university library and how, at the same time, it supplements the activities and resources of both. The most satisfactory definition is that suggested by Linda H. Morley:

> A special library is a service organized to make available all experience and knowledge that will further the activities and common objectives of an organization or other restricted group, with a staff having adequate knowledge in the field of specialization and the activities of the clientele, as well as professional preparation. Its function is (1) to assemble information from published sources both within and without the library, (2) to secure information directly by correspondence and interview from individuals and organizations specializing in particular fields, and (3) to present this information at the appropriate time and place on the initiative of the library as well as upon request, that it may take an effective part in the work of the organization or group served.
>
> Policies, methods, and collections vary, on the one hand according to the library's subject interests: economics or business, social sciences, sciences and technology, or the fine arts; and on the other hand, according to the type of organization of which the library is a part: a corporation, association, or institution, government office, or a general library having definitely decentralized departments.

From this it will be seen that, although special libraries are created to serve a particular clientele and are frequently separate entities, they are not divorced from other libraries. Their chief distinction lies in the fact that they devote themselves almost exclusively to one specialized field and one group of users.

Our definition calls the special library a *service*, and this is one of the most important points in the description. Created with the purpose of "putting knowledge to work"—the incisive slogan of the Special Libraries

Association—these libraries, with their variety of resources, meet the demands of many types of people; and service is the underlying motivation of each of them.

No static thing, no mere depository of books and pamphlets, the special library is alive, and takes numerous interesting forms. It may consist of a few books, several periodicals, a few filing cases, and a well-trained librarian; or it may consist of several thousands of volumes, large collections of bound periodicals, a battery of filing cases, and a complete catalog, with a staff of several professional librarians, translators, and subject consultants. It may be organized as part of a larger library, with special rooms of its own; or it may occupy an entire building, complete with stacks and special reference and workrooms; or, as frequently happens, it may occupy a corner in a laboratory or business office. Whatever its size and however modest or impressive its quarters and appearance, its sole purpose is to serve the organization of which it is an integral part. Actual methods of service may vary, but the organization that wants facts and information rather than presumptions finds the well-organized library the most efficient research tool and the greatest economy in the time and effort spent on research functions. Not only is information readily available, but duplication of research efforts is precluded. Errors resulting in heavy loss of time can be avoided by having information available in libraries close at hand.

THE special librarian, aware of the activities of the organization the library serves, does not wait for readers to come to the library. On the contrary, by means of library bulletins and routing of periodicals and other materials, he takes the library to the rest of the organization and helps to keep the entire staff abreast of recent developments in relevant areas of interest. Products being developed (if the library is part of an industrial organization) or (in other types of organizations) the special research being done by an editor or a historian or a physician are of particular interest to the librarian, and he is guided by his knowledge of these activities in determining library needs and anticipating services. Being more than a mere library technician, he finds it necessary to acquaint himself as thoroughly as possible with the subject fields in which he is working and to be especially prepared to recognize information of immediate or potential value to his clientele. The special librarian realizes that his professional library-school training is only a beginning. Although he must be an efficient library specialist, familiar with library administration and technical procedures, he must go further and learn the methods, character, and present and future aims of his organization before he can be of full value. It is usually recognized that in-service activity, with participation in departmental meetings, planning groups, and discussions of policy, is necessary to complete his training and to enable him to function with maximum efficiency.

Books, periodicals, newspapers, pictures, and maps form the basic materials of most library collections, but these do not constitute the only sources of information in special libraries. As many media are to be found as there are means of transcribing thoughts and ideas. There are mimeographed and other processed reports, letter reports, circulars, dissertations and theses, trade catalogs, and many other apparently ephemeral forms that frequently contain unique documentary source material necessary for research in numerous fields. In addition, special libraries often include phonograph records, films, lantern slides, photographs, metal cuts, textiles, ceramics, herbarium specimens, and other material usually considered characteristic of museums. In discussing special libraries, much emphasis is always placed on their

function of providing current information. This is indeed one of their outstanding attributes, but it would be a serious error to conclude that they lack background or historical material. To say that they are of "limited use to the scholar," as one university librarian did some time ago (SM, June 1946, p. 515), is misleading and does a disservice to the scholar. Any librarian is witness to the fact that there is a wealth of source material in these special collections that no serious student can afford to ignore.

Acquisition policies and the collection programs of special libraries in the same fields often differ. Some libraries concentrate on providing only the most up-to-date material; some collect mainly historical data; and some, probably the majority, attempt to include both current and historically important background material. Methods and policies of acquisition are always based on the work of the organization, and form the No. 1 administrative problem of the library.

Sources of acquisition are many and often complicated. They must be completely familiar to the librarian. Standard trade bibliographies, book-review sections of newspapers and general literary magazines, and national bibliographies of the United States and other countries are consulted as a matter of course, but there are many other, less obvious sources. The subject periodicals for each field are sources to be checked; the lists of documents published by our Federal, state, and municipal governments, as well as those published by foreign governments; rare bookdealers' catalogs; subject acquisitions lists published by other libraries; publications of professional organizations, such as the *Technical Book Review Index*, published by the Special Libraries Association, and those of research organizations—all must be familiar to the special librarian and be studied regularly. These sources differ in each field, but the librarian often finds it necessary or profitable to search the special publications of other fields for related materials. After studying all available sources, discrimination in selection must be exercised. The collections of librarians specializing in current or ephemeral types of literature frequently change in emphasis as fields of knowledge expand, and often disclose the latest developments and directions of expansion in the subject fields of interest. It is no exaggeration to say that many alert librarians lead the way in dictating new fields of research, because, in their association with other librarians and their frequent literature search, they turn up references the research staff has not had the opportunity to find.

Much ingenuity has been shown in the arrangement of special library collections. This is an important point because, if the library material is not arranged logically and conveniently, it loses much of its value. Classification and cataloging schemes are always selected according to the type of collection and the use to be made of it. These are often the standard systems used in general libraries, but revised or expanded to suit the collection at hand. The familiar dictionary catalog that includes author, subject, and title cards in one alphabet may be abandoned in favor of either a subject catalog, with a separate author catalog, or a classified decimal system catalog such as that in use in the Engineering Societies Library in New York. Sections of the Dewey Decimal Classification may be expanded to take care of large collections on international law, aeronautics, and other subjects; or a standard classification scheme may be given an entirely new interpretation. Subject headings for the catalog (the words used to describe the contents of books) are devised especially to cover the collections in individual libraries and may be completely new, or they may supplement those in standard lists such as the Library of Congress subject headings list.

Care is constantly exercised to keep these headings up to date and to provide for the correlation of old headings to new or related ones. Special indexes and catalogs sometimes supplement standard systems, bringing to light materials buried in one classification under different headings, and relating subjects to one another in such a way as to make them more readily usable. This function of special, tailor-made arrangements cannot be overemphasized, since it forms the basis of value of many collections that might otherwise be of no more importance than any other collection in the same field.

The special librarian does not limit himself to the resources of his own collections in providing library service. Cooperation with other special libraries provides materials through interlibrary loan, in which case volumes may be borrowed from other organizations; or, if this is not possible or practical, photostatic and microfilm copies of required material may be secured. Frequently, extensive information is secured by correspondence. Special libraries have been most active in supporting schemes for interlibrary cooperation and have contributed fully to union lists of serials, regional catalogs of books, descriptive manuals of resources, and other projects that underlie such cooperation. Working along with the large general library, the special library often supplies advance information of a highly specialized nature, which the former is not expected or designed to provide; in a reverse manner, the special library often depends upon the large public library for long runs of periodicals and historical works, which it would be impossible or impractical for the smaller library to acquire and store because of cost and lack of space.

In the special library much time is spent on such activities as compiling bibliographies, searching out source materials, preparing abstracts of books and periodicals, making patent searches, translating foreign publications, and indexing special materials. Thus the researcher and busy executive is saved time and is frequently made aware of information he did not know existed.

One of the best means of understanding the extent of special libraries, the fields covered by them, and the services they offer is to examine *Special Library Resources*, a publication recently issued by the Special Libraries Association. More than 2,400 special libraries in this country and Canada are listed in four volumes.

The general arrangement of information is alphabetical by state, and then by city and name of organization within each state. Each entry includes the name of the organization and its library, its address, the names of the librarian and of the person to whom he is responsible, the number of persons on the staff, the specialists and translators available, and the personnel served. There are special libraries located in almost all types of communities, from villages to the largest cities. Staffs range from one trained librarian to fifty or more; the clientele served may be restricted to the organization alone, or it may be joined by members of the community. In noting the services of available specialists, not only are those regularly employed in the library included, but any available elsewhere in the particular organization or vicinity. Interlibrary loan privileges, whether limited or liberal, are stated, with information on reproduction equipment such as photostat or microfilm.

Descriptions of the collections in these libraries include the subject fields covered and often are given in considerable detail. Their resources are divided into the following classifications: books, periodicals, and the disposition made of them; newspapers; pamphlets; and the number of vertical file drawers. Significant and uncommon holdings are indicated by title, and unusual

collections are described. Union lists such as the familiar *Union List of Serials* are noted when the library has reported its holdings.

Periodicals or serials not included in any existing union list are noted, as are special subscription indexes and abstract services received, such as *Science Abstracts*, *Ceramic Abstracts*, *Engineering Index*, and *Public Affairs Information Service*. Many of the libraries described maintain special indexing and abstracting services that are unique, and these also are listed. Interesting examples, typical of the service offered by special libraries, are the bibliography on physical oceanography in process at the Scripps Institution of Oceanography, the index of periodicals relating to lumber reported by the library of the National Lumber Manufacturers Association, and the index of literature on stainless steel in the library of the Rustless Iron and Steel Corporation.

ORGANIZED in 1909, the Special Libraries Association is the national professional group to which special librarians belong. It is dedicated to the promotion of high professional standards for libraries and library personnel and functions as a clearinghouse of information for its members and persons interested in organizing new libraries. *Special Library Resources* and the *Technical Book Review Index* are only two of many valuable reference tools sponsored by this association; they do, however, typify the work of the organization in this field. Over 4,800 members are organized into subject groups as follows: Advertising, Biological Sciences, Business, Financial, Geography and Map, Hospital and Nursing, Insurance, Museum, Newspaper, Religious, Science-Technology (with Chemical and Public Utilities Sections), Social Sciences, Transportation, and University and College. In addition, chapters composed of the same subject groups are located in the main centers of population across the country. This geographical distribution permits frequent meetings throughout the year and facilitates local and regional cooperative projects.

The unique functions of the special libraries were high-lighted by John A. Lapp, a pioneer in the field, when he said:

> It may be said that wherever there is a problem of government, of business, of finance, of manufacturing, of commerce, there the idea of knowing all there is to know about the problem must certainly prevail in the hands of men who think and who act upon information, rather than upon the rule of thumb. The extension of this idea (by means of the special library) means that the great storehouses of knowledge which have been created throughout the ages and which are being added to daily by research and investigation shall find a means of making the knowledge which they possess articulate in everyday affairs. Instead of being hidden in the resources of the general library, or instead of being scattered and uncollected, it will be focussed upon the jobs which men perform and will help in the solution of problems which come.... Enough knowledge is stored up to solve a great many of the problems of the day if channels were open between the storehouses of information, the executives who control policies and the men who carry them out.

In those few words, then, lies the meaning of special libraries.

AN INDUSTRIAL RESEARCH LIBRARY

By LUCY O. LEWTON

Miss Lewton (M.A., Columbia) has been in industrial research laboratories in various capacities since 1922. She is the author of two U. S. patents, one of which is "A Process for Removing Harsh Constituents from Tobacco." During the war she was Chairman of the Cooperative Abstracting Group on Conservation and Substitution of Strategic Materials for the WPB. At present Research Librarian at the Central Research Laboratories of the Celanese Corporation of America in Summit, N. J., she is also Chairman of the Science-Technology Group of the Special Libraries Association.

IT IS a long way from the medieval "Alchymyst" working alone in a dark, cluttered cell among his alembics and brick furnaces, as pictured in the Teniers paintings, to the groups of modern investigators in an air-conditioned research laboratory, yet it is significant that the large tomes and parchments of "recipes" consulted by the alchemist have retained their importance to research under the more modern guise of special science libraries. Systematic techniques of literature research as a forerunner of actual laboratory work have become the modern counterpart of the random poring over manuscripts that accompanied the alchemist's hit-or-miss search for the philosophers' stone. For, just as the distillation column has replaced the alembic and the electric oven the brick furnace, so the cryptic recipes of the alchemist as a means of recording results of scientific research have been superseded by detailed monographs, communications to scientific journals, articles in trade and professional journals, patent specifications, and unpublished company research reports.

This ever-mounting flood of recorded results of the world's scientific investigations, evidenced by the fact that 30,523 articles were indexed by *Chemical Abstracts* in 1943 as against 19,507 in 1923, has demanded that specialized subject collections be formed and special systems developed for evaluating, classifying, digesting, and storing these observations lest they become lost as a maze of isolated and, what is worse, unapplied facts.

Particularly is it important in the concerted attack now being made on the secrets of nature, in which all the sciences are marshaled (as exemplified by the cooperative programs on nuclear fission to be carried out at Brookhaven and Argonne National Laboratories), that no grain in that vast storehouse of tested facts be lost.

The amount of money spent on "pure" research by government, universities, and industry in 1947 is estimated at 335 million dollars, or five times that spent ten years ago. Industry alone invested 75 million dollars in research during the war, and about 2 percent of annual gross profits is invested by manufacturers in research. Yet the line between pure, or theoretical, and applied research is not so sharply drawn as formerly: much so-called pure research carried on at universities today is done to build a foundation for the new industries of tomorrow; and the list of corporations expanding their research activities or building laboratory centers this year reads like a "Who's Who of American Industry."

All this intensification and expansion of scientific research has had a concomitant effect on the development of scientific libraries. The membership of the Science-Technology Group of the Special Libraries Association has risen to 2,000 persons, employed in 950 different scientific libraries, of which about 350 are industrial research

libraries. Many of these are in connection with the laboratory research centers of the respective companies. Staffed with technically trained librarians, these company libraries have extensive specialized subject collections that it would be hard to duplicate elsewhere. They are, in fact, reference authorities in the fields in which the laboratories or the company operate and have conveniently collected and suitably classified in one place material which, in an institutional or public science library, is scattered over many locations and topics.

Since we have a competitive economy, industrial research must keep in touch with the progress of its contemporaries, as well as build up that body of best-ways-of-doing-things that is technological "know-how." The industrial research library, therefore, becomes not only the first point of attack on a problem, but also a repository of the company's technical experience as reflected in its own research reports and unpublished technical data, eliminating duplication in further investigations.

A science library differs from special libraries in other fields not only in its sources and subject matter, but in the characteristic importance of patent literature and the well-developed abstract journals.

Since in industry time is of the essence and a more select clientele is served, the science library must be less according to Hoyle than the straight library; it must be more specialized, with short cuts and with a technique more intelligible to the busy scientist-user; it must also allow for a detailed knowledge of the subject matter on his part. For example, contents of books must be more carefully evaluated, and special detailed treatment of a given phase of a subject noted. Often it is important to know, for instance, that of all books on fractional distillation only one certain text mentions the effect of the number of plates on the efficiency of a column; or that one text describes aldehyde resins in detail, whereas others have but a passing mention of them.

Subject headings or cross references must be more extensive, up to date, and in the nomenclature actually used in that technology and industry. Dictionary-type, significant-word indexing often is impossible to use, for an article under "Anodic cleaning" would be separated from "Electropolishing," although both are the same technique. Owing to the rapid strides in technology, the subject catalogs of an industrial research library need constant revision, because subjects that yesterday were merely obscure aspects of some industrial method, today may be the centers of special industries and be acquiring a patent literature of their own.

Although admittedly texts form only a minor part of a special library, in a science library they serve as convenient summaries of accepted practice, used more for general orientation than as sources for literature research. Book selection in an industrial science library, therefore, must be a censored activity, exercised with more judgment, perhaps, than in the case of libraries where completeness of bibliographic collections is sought. Periodical literature as a source of new developments supplies more up-to-date information, much of which never appears in books in so detailed a form. This original literature is also better indexed in the abstract journals such as *Chemical Abstracts*, *British Abstracts*, and *Science Abstracts*, which are the basic search tools of a science library. The journals in the different and now-overlapping branches of the sciences, numbering 4,318 of chemical interest alone, form too large a body of printed material for even the most generously endowed industrial research library to own.

Often the most valuable sources in an in-

dustrial research library are neither texts nor long sets of bound periodicals, but special collections of patent specifications, pamphlets, trade literature, and the subject catalog of abstracts from current literature, all expertly indexed from the particular viewpoint of the problems being investigated or the interests of the company. Such files, supplemented by the unpublished research and progress reports of the company's investigators, can be the heart of an industrial research library, whose quality and value can hardly be measured by the size of its shelf possessions or the number of its books, but rather by the speed with which pertinent information is produced upon request.

The industrial research library differs likewise from other types of science libraries in the kind of service needed and expected. Whereas the large repository library may be consulted by the scholar who wishes to pursue his detailed studies on possibly but a single topic, the industrial research library is apt to be consulted by the salesman, the production man, and the financial executive, as well as by the scientific investigator. It is expected to be not only up to date in its collections but also, keeping pace with the changing program of research in the laboratories, to be able to offer on the spot at least some background information on the greatest variety of scientific topics. For the investigator, such a library makes long-term literature and patent searches, culminating in the literature-survey report that precedes work on a new project. Such a survey may analyze the factors involved in a problem, give types of technique and apparatus to be employed, and open up a whole vista of as yet unexplored avenues, since its object is to make known what has been done before.

Keeping abreast of new developments as mirrored in the trade and technical magazines, not only for the sake of maintaining resources and information, but also for the purpose of calling the attention of the investigator to an item that can guide or stimulate him in his research, involves a constant review of magazines and patents and the issuance of abstracts in the form of a periodic library bulletin. Such a publication, if it includes news of trends in the industry, adds to the general industrial education of the whole scientific staff.

Most of all, the day-to-day furnishing of isolated information, called reference work, is the chief product of the industrial science library. The kind of questions asked may vary from the current price of a raw material or a chemical of commerce to methods of determining viscosity of synthetic latexes, which involves searches in German technical reports on microfilms. The library's answers to such questions not only expedite research but may actually stimulate discovery and invention. Stories of actual discovery made through library research, table talk whenever a group of technical librarians get together, show that even "geological reconnaissance" can be done in the library.

Obviously, these functions require mental agility, for the technical librarian in industry is not merely the curator of a collection, but an actual researcher whose tools are the materials in the collection. Preeminently, this type of librarian must, like the research scientist, be a subject specialist, in order that he may properly interpret a request and correlate the information he finds; moreover, he must be well oriented in all the basic sciences and conversant with the practices and the state of the art in the particular industry. He must know at least three modern languages and be aware of the accepted terminology of the several sciences. Finally, the library researcher must be cognizant of patent procedures, the economics of research, and marketing, or end uses of the products of research.

Library research, as exacting and as painstaking, and offering as much opportunity

for creative ability as laboratory research, is attracting both men and women who, besides a broad training in the sciences, have a literary bent, an eye for the historical aspects of science, and are possessed of the administrative ability to plan and lay out the many orderly routines of a library.

A CLOSE-UP of the functioning of an industrial research library is possibly best obtained from a consideration of an individual library. Among the important industrial research libraries is the Central Library of the Celanese Corporation of America, recently established at the Research Laboratories of the corporation in Summit, N. J. It covers the fields of textile and plastics technology and cellulose chemistry; serves about 150 chemists, physicists, researchers, and development engineers. It has a staff of three clerical and three technically trained personnel. This library represents the merger of two sources of technical information previously existing within the company. One was the Library and Data Files of the old and well-known Celluloid Company, of Newark, N. J., which ultimately became the plastics subsidiary of the Celanese Corporation. Organized for the purpose of supplying the literature and patent information for the Development and Research Department of this subsidiary, this library had built up extensive files on the history, fabrication, and uses of the cellulosic plastics, and on plasticizers and organic chemicals; it also had a complete collection of patent literature on these and related subjects. The other library was that of the Amcelle Research Department at the Cumberland, Md., cellulose acetate textiles subsidiary. It had extensive book and bound-periodicals holdings, dealing chiefly with textile chemistry, dyeing, physical testing, and allied topics.

When, in 1944, it was decided to centralize the research activities of all branches of the company at the new laboratories at Summit, plans were made to centralize the research library also. Accordingly, the list of books and bound-magazine set holdings of both libraries was evaluated, first, by the scientific staff that was to be transferred to Summit; second, by the chief of the Patent and Data Division, under which the new library was to operate; and, finally, by the Research Librarian. In this way a collection of about 1,000 book titles, 117 magazine subscriptions, and 108 sets of bound journals was put together. The book collection was then entirely reclassified, using a simplification and modification of the Dewey Decimal System, with considerable expansion in the classes of organic chemistry, textiles and plastics, and elastomers.

The special files consist of general data material (photostats, clippings, pamphlets, and reprints), equipment and materials catalogs (including trade literature of other plastics manufacturers), and patent specifications. This material is considered published data, is indexed with an abstract on 4″ x 6″ cards, and filed by a classified subject heading scheme, with individual subjects assigned numbers under which the original material is filed. It is available to all users of the library. Experiments are being carried on in the use of punched cards for indexing this material.

Supplementing these special files, and considered an important source of information, are the research report files of the company kept in the Data Department. As much of this is unpublished material, it is very carefully indexed by subject.

The Central Library compiles major bibliographies; makes translations and patent searches, working in close collaboration with the chemist in charge of patent work; and answers approximately 15 requests for spot information per day. Its routine, aside from ordering all printed matter for laboratory researchers and the circulation of current magazines to them, includes the review of

about 75 journals, abstracting from these significant items of interest for its abstract subject file and for the attention of individual investigators. The publication of a library bulletin of abstracts is at present under consideration. The *Patent Gazette* is reviewed, and specifications ordered by the Patent Chemist are carefully indexed by subject, number, and assignee.

Among administrative duties, the Central Library is charged with classifying all books received in the company. A Union Catalog of such books, giving their "branch" location is maintained by author and subject in the Central Library at Summit.

Other libraries of the company are located at the Newark, N. J., Plastics Development Division; at the Amcelle, Md., Textile Development Division; and at the Rome, Ga., Viscose Plant. A library has recently been organized for the executive office in New York City to deal with the economics and management aspects of the textile industry; and a library on petroleum chemistry and technology is being assembled for the Petroleum Research Laboratory of the company in Clarkwood, Texas. It is hoped to weld these into a system of libraries, each becoming reference specialists to serve all the branches of the company with the information that each library is best suited to produce. Thus, in this one large industrial company the various units of technical information are being coordinated with its centralized scientific activities.

As Arthur D. Little, head of one of the largest industrial laboratories, once said: "Since it is the function of the laboratory to extend our knowledge, it cannot function properly unless its working units are strengthened and refreshed and stimulated by the constant stream of facts, theories and opinions which it is the purpose of the library to supply."

YE SHALL KNOW THEM BY THEIR FRUITS

The faith of old bestowed on God
Is due to Science, some impute.
To Science this seems very odd,
But Time *with logic absolute*
Declaims no man can understand
What Einstein proved with figures queer,
That we must take our faith in hand
And blindly follow this great seer.

Saint Matthew said fruitions prove
The prophets true or else deficient.
The blast which makes a tyrant move
To end his war is proof sufficient
That product of the square of C
And M *will make a lot of* E.

PAUL D. HARWOOD

THE AIR UNIVERSITY LIBRARY

By WAYNE S. YENAWINE

A graduate of the University of Illinois Library School in 1934, Mr. Yenawine (M.A., Illinois, 1938) has been associated with university libraries ever since. He was a logical choice, therefore, for the post of Director of Libraries at the Air University, Maxwell Field, Ala., where he has been since May 1946.

GENERAL CARL SPAATZ, in speaking to a group of California educators, said,

> We in the Air Force have realized that our own education must be geared to a global concept of war and peace. It is not enough for air men to be technicians. They must be versed in human affairs; they must be educated up to the standard required by the history-changing role of air power.

To implement these educational objectives, Air University was activated March 15, 1946, and its first classes started on September 3, 1946. The component schools and colleges of the university include the Air Tactical School, the Air Command and Staff School, the Air War College, The Special Staff School, and the School of Aviation Medicine. The university is responsible for the selection and progress of officers enrolled in civilian universities, for the preparation and review of extension courses, for training and supervision of AAF instructors at non-AAF schools, for supervision over the curriculum of the Army Air Forces Institute of Technology, Dayton, Ohio, and for research in the employment of air power. The Air University thus integrates the educational functions of the AAF into a system of higher education.

Conscious of changing concepts and keenly aware of changing requirements of officer personnel, the Air Force created Air University to provide its officers with a broad, comprehensive education. This education is conceived as a continuing process, beginning soon after the completion of the officer's flight training and extending over a twenty-year period in his career. The levels of instruction are higher than ever before attempted by the AAF, and they correspond to postgraduate education in civilian universities. Emphasis is twofold: first to furnish officers with factual knowledge, skills, and techniques; second, to develop the officer's ability to think clearly, accurately, and objectively about the future doctrine, tactics, and strategy of air power.

Establishing a new university meant establishing a new library. The accelerated development of a research library simultaneously with organization of the faculty, staff, curriculum, education policy, plant facilities, etc. revealed the vision and tenacity of the Commanding General, Muir S. Fairchild. Materials, personnel, equipment, and building for the library shared top priority among the multitudinous problems that faced the small group of officers who had abruptly turned from combat to higher education. The first decisive steps included the requisition and removal to Maxwell Field of a collection of 10,000 volumes, 25,000 military documents, and several thousand maps that had supported the AAF School of Applied Tactics, then recently inactivated. A Director of Libraries was selected and appointed. Standard library equipment was requisitioned; some was shipped to Maxwell Field from inactivated AAF base technical libraries. A strategically located one-story building was selected, and its 14,000 square feet of floor area remodeled into a functional library building. These steps were accomplished in three incredibly short months in the spring of 1946.

The Air University Library capitalized on

the momentum of its running start and during the first year realized professional potentialities considerably beyond expectation. To printed resources have been added 22,000 volumes of books and bound periodicals; 50,000 restricted military documents; 75,000 maps and charts; a special reference library of 20,000 documents on the arctic, desert, and tropic regions; the Layne Library, containing 3,800 documents on military intelligence; the Hardwick collection of Air Staff intelligence requirements of the Far East; and a collection of approximately 100,000 archival documents pertaining to the history of Air Force operations. To the personnel resources have been added twenty-five professional, sixteen subprofessional, and four clerical staff members. A complete microphotographic laboratory has been added to the library's equipment. Library activities expanded into two additional buildings at Maxwell Field, and during the first year two branch reference libraries were established: one for the Air Tactical School at Tyndall Field, Panama City, Fla.; and the other for the Special Staff School at Craig Field, Selma, Ala.

These tangible developments of the library are obvious and essential to the educational mission of Air University. More fundamental considerations, however, are the extent to which these resources contribute to that educational mission and whether they contribute lasting benefits to the officers for whom they are intended. In this connection, the library was planned as a resource laboratory where officers will be stimulated to reach new horizons in their thinking and where they can explore the past in printed record under favorable conditions. The concept of a resource laboratory assumes a close relationship between instructors and resource use, and conditions are basically more favorable at Air University than at many civilian universities.

The instructors, all Air Force officers, were hand-picked because of their brilliant operational records and because of their outstanding capacity for dynamic leadership. As a group they are young, enthusiastic, and receptive to the program of Air University. What they lack in teaching experience is balanced by a freedom from pedagogical dogma and an eagerness to learn the techniques of managing seminars, supervising theses, developing student ability for critical thinking, evaluating resources, etc. The instructors have found the Air University Library a new experience in their careers and are intent upon learning the mysteries of card catalogs and classification schemes, their responsibilities as book selectors, their obligations to the student in bridging the gap between class discussion and resource use, and similar duties of a faculty, which librarians generally take for granted.

The instructors' lack of experience in teaching and in using university library facilities explains some of the unique features in the library's organization. Since the faculty is in the process of being indoctrinated, they are not ready to exert any appreciable influence in book selection. Those whose military careers began just prior to or during World War II found support for their combat assignments primarily in military source materials. In contrast they are realizing that the resources needed to support their teaching assignments in such fields as logistics, air intelligence, and strategic use of new weapons cut across many subject fields and embrace a wide variety of published forms. Until such time as Air University can develop a corps of great teachers for the Air Force, the library will assume the major responsibility for developing adequate materials resources.

Professional personnel for the library division were selected so as to provide within the staff a variety of subject specializations. Through a division of responsi-

bility among individual staff members, emphasis has been given to all pertinent subject fields. Very little emphasis has been given to contemporary national literatures since the literary product of the world is significant to local needs only as it reveals objectives of foreign propaganda. During the first year 15,000 volumes (books, reference sets, files of periodicals, and serial publications) were selected by the library staff and purchased by the Acquisition Department with a $70,600 appropriation from the AAF library book fund.

The acquisition problem in the Air University Library involves military documents as well as commercially published materials. The military documents, classified for security reasons as *restricted*, *confidential*, *secret*, and *top-secret*, are difficult to locate and obtain since there are no bibliographic summaries comparable to the *Cumulative Book Index*, and since the importance of many documents to national security tends to limit distribution and discourage dissemination of information about them. When Air University needs military documents, the library, in most cases, must exert its initiative to verify their existence, locate copies, and expedite acquisition through its own resourcefulness. The Collection and Analysis Section, composed exclusively of military personnel, was provided to define the university's requirements of military documents based upon an analysis of the curriculum and upon available resources, and to select, locate, and obtain the documents needed for instruction and research. The familiarity of the faculty with military documents has enabled instructors to render invaluable assistance in this activity.

Just as book selection has been a major responsibility of the library, so also have been the evaluation of materials, guidance in using bibliographic techniques, and instruction in methods of documentary or historical research. The Air War College and the Air Command and Staff School ask each student officer to prepare a thesis as a requirement for graduation. Most of the students have not had appropriate experience as background for such an assignment, and few of the instructors are prepared at this stage of the university's development to offer the students more than a critical appraisal of the doctrine, concept, or proposal contained in the finished thesis. From a realization of this situation grew the need for a Reference Department experienced in working with graduate students, and for the special staff of the Documentary Research Section, composed of productive scholars who have held research professorships in civilian universities. The staff of the Documentary Research Section works constantly with the research resources of the library and is developing specializations in areas of literature covering the Use of Air Power in the Polar Regions, Mobilization of Economic and Political Resources in Support of Air Power, Air Defense of the United States, Technological Research and Development, and Air Intelligence. Members of the library staff enjoy a close relationship with student officers and have opportunities in student guidance generally performed by the professor in civilian institutions. The experience has been stimulating to the staff and helpful to the students.

Resources in the library are made as accessible to the user as possible consistent with security regulations. Materials with a security classification are located in a restricted area and serviced by the reference librarians. All other materials are immediately accessible to the user, and orientation is provided to increase the user's resourcefulness in the library. The faculty receives information about the library in an in-service instructor-training course, and specific information is given each member in an *Instructor's Handbook*. At the time assignments requiring use of the library are given,

students attend lectures given by the staff on documentary research techniques, thesis writing, and use of the library. The lectures are followed by a tour of the library, and each student is given a *Library Handbook*. More effective than any other agency, however, is the personal instruction given users of the library in connection with their need for the selection of subject materials, evaluation of sources, or location of data. The purposes of library instruction are to lead, direct, and train the reader to use the Air University Library effectively and to develop a learning process that will carry over beyond his formal education.

It is significant that the Air Force wants well-informed, widely read officers who are capable of using air power to preserve the peace. The library faces the challenging task of influencing the self-education of officers throughout the Air Force by stimulating more independent reading and by raising the general level of reading. The logical starting point in this activity is with Air University students. The library has assisted instructors in selecting not only assigned reading but collateral reading as well. The instructors encourage discussion in the class and seminar about current controversial issues of national or world importance and about current publications. These discussions have been coordinated with the library, and the staff has sustained some of the student interest through the display or suggestion of pertinent materials. A permanent display in the library contains recommendations for an officer's private library, and an annotated bibliography is available for distribution to all students and visiting officers. A reading list has been prepared for independent reading, and the titles included are grouped according to the reading interests of junior, staff, and command officers. This list was mailed to all Air Force officers on active duty, with the suggestion that selected reading be accomplished in preparation for future enrollment in Air University.

These are only a few of the activities and problems of the Air University Library. The establishment of a new research library creates some problems the older libraries were spared, but it also creates new opportunities that the older libraries are denied. As the library program for Air University evolves the record will show how well those opportunities have been used.

THE GEOLOGY OF SHAKESPEARE

By BRADFORD WILLARD

Dr. Willard (Ph.D., Harvard, 1923) has been head of the Department of Geology at Lehigh University since 1939. In pursuit of his vocation he has published more than one hundred articles on geology, chiefly on the Paleozoic stratigraphy of the Northern Appalachians, particularly the Devonian of Pennsylvania. He devotes his spare time to Shakespeare.

TO William Shakespeare has been attributed the gift of omniscience. From his writings one may select passages that to modern eyes appear to support this attribution. That he could not possibly have had any knowledge of geology as we today understand it is axiomatic. The science was not even named until about the mid-eighteenth century. Still, just as one might quote from Shakespeare's writings passages on biology, mathematics, and other branches of human knowledge, so one cannot deny that his plays and poems contain many references to geologic phenomena and to objects of geologic significance. Has he ever been given credit for occasionally sounding a geologic note? Being myself a Shakespeare addict by avocation and a geologist by vocation, it is inevitable that I have noticed passages such as "the flinty ribs of this hard world" (*Richard II*, V, 5, 20–21). I have brought together my findings, but I make no claim that Shakespeare was a geologist or had any special insight into earth science. How many of the passages I have culled are the consequences of his own observations, how many he acquired through hearsay, or how many may have been lifted from extant written accounts, I shall not attempt to differentiate. By no means do I presume to have unearthed every possible citation; much less shall I quote all those that I have found; still less can I attempt to cover every ramification of geology upon which Shakespeare's works touch. What I wish to emphasize is that his writings indicate what was commonly known by Elizabethans of the fundamentals of geology.

Ever since some early forebear of ours discovered that of all stones, flint made the best weapons and tools, man has exploited flint. With that exploitation, geology had perchance its first application to the needs of primitive man. Early civilizations recognized geologic phenomena. From Isaiah's preaching, "Every valley shall be exalted, and every mountain and hill shall be made low: and the crooked shall be made straight, and the rough places plain," one must infer inklings of physiographic processes. How far more realistic are his lines than Jacob's misconception of the "everlasting hills." Greek and Roman thinkers added their bits to geology. The unlearned peasant has long had his rule-of-thumb weather proverbs, has known something of the occurrences, uses, and values of rocks and minerals, the ways of flowing streams, the significance of springs of water, the characteristics of mountains, and the disasters of the earthquake and the volcanic outburst. Early mariners contributed the germ of oceanography. In 1546 Georg Bauer ("Agricola") summarized in *De re metallica* most of what was then known of mining. There is considerable geology in this classic, but, if Shakespeare ever saw a copy, he was not so impressed that he let it influence his writings.

In drawing upon Shakespeare for allusions to geology, I have confined my choice to the more earthy branches: physiography, lithology, mineralogy. Some passages found are farfetched, and some allusions or connotations if quoted would entail long explanations. I have passed most of these by and present only the more obvious. Though

I omit most citations on meteorology and climate, there are many passages on storms, frost, snow, hail, rain, dew, thunder and clouds, wind and calm, climate and the seasons. I cite only those vivid St. Elmo's fire lines from *The Tempest* (I, 2, 196–206):

I boarded the king's ship; now in the beak,
Now in the waist, the deck, in every cabin,
I flamed amazement: sometimes I'ld divide,
And burn in many places; on the topmast,
The yards and bowsprit, would I flame distinctly,
Then meet and join. Jove's lightnings, the precursors
O' the dreadful thunder-claps, more momentary
And sight-outrunning were not: the fire and cracks
Of sulphurous roaring the most mighty Neptune
Seem to besiege, and make the bold waves tremble,
Yea, his dread trident shake.

Shakespeare's works include frequent references to seismic disturbances. The trembling land finds passing recognition in *All's Well That Ends Well* (I, 3, 91–92); *As You Like It* (III, 2, 195–196); *Henry V* (II, 4, 100); *Henry IV*, Part I (III, 1, 16–17); *King John* (V, 2, 42); *Much Ado About Nothing* (I, 1, 275); *Pericles* (III, 2, 15); *Romeo and Juliet* (I, 3, 23); *The Tempest* (II, 1, 315); *Venus and Adonis* (line 648). A passage from *Henry IV*, Part I (III, 1, 28–33), is interesting as it reflects the lingering influence of the Roman Lucretius (*circa* 50 B.C.), who, with others of his time, attributed seismic disturbances to winds in subterranean vaults:

oft the teeming earth
Is with a kind of colic pinch'd and vex'd
By the imprisoning of unruly wind
Within her womb; which, for enlarging striving
Shakes the old beldame earth and topples down
Steeples and moss-grown towers.

In contrast to earthquakes, volcanism is given short shrift with such brief citations as those to Mount Aetna in *The Merry Wives of Windsor* (III, 5, 128) and *Titus Andronicus* (III, 1, 242). Perhaps the difference in emphasis reflects personal experience. Shakespeare himself probably witnessed, or at least talked with witnesses of, English earthquakes, which, though unknown of the first magnitude, can be impressive. On the other hand, he probably never experienced the terrors of an active volcano.

Minerals, jewels, precious stones, gems, and rocks all have places of honor in Shakespeare's writings. Omitting such stereotyped comparisons as eyes to diamonds and lips to rubies, there are plenty of references to jewels and gems. That something of their true as well as fancied or supernatural attributes, baneful or beneficial, was understood is demonstrated by lines 211–217 of *A Lover's Complaint:*

The diamond, why 'twas beautiful and hard,
Whereto his invised properties did trend;
The deep-green emerald, in whose fresh regard
Weak sights their sickly radiance do amend;
The heaven-hued sapphire and the opal blend
With objects manifold; each several stone
With wit well blazon'd, smiled or made some moan.

The old idea of fabulously rich deposits of precious stones in the ocean's deeps is evinced in such a phrase as "the sea's rich gems" (Sonnet XXI, line 6), and implied in *The Tempest* (I, 2, 396–398):

Full fathom five thy father lies;
Of his bones are coral made
Those are pearls that were his eyes.*

Although the word "adamant" recurs somewhat often, it may not invariably refer to the diamond, because adamant was also used for the lodestone, as implied in "You draw me, you hard-hearted adamant," from *Midsummer Night's Dream* (II, 1, 195). Agate is mentioned in *Henry IV*, Part II (I, 2, 18–20), and Shylock (*Merchant of Venice*, III, 1, 125–126) bemoans the loss of his turquoise. Of nonprecious minerals, the list is only fairly impressive. Jet is

* Cf. the lines from Gray:

Full many-a gem of purest ray serene
The dark, unfathomed caves of ocean bear.

cited in *Henry VI*, Part II (II, 1, 112). From *As You Like It* (I, 3, 114) comes "of umber smirch my face." Sulphur finds a place in *Coriolanus* (V, 3, 152) and in *Cymbeline* (V, 5, 240). "Burn like the mines of sulphur" is quoted from *Othello* (III, 3, 329). Amber, by some purists not conceded to be a mineral, *sensu stricto*, yet surely of geologic interest, appears in *Hamlet* (II, 2, 200–201) and in *Love's Labor's Lost* (IV, 3, 87); and reference to its use as an object of personal adornment may be read at least twice: "amber bracelets, beads" (*The Taming of the Shrew*, IV, 3, 58), and "neclace amber" in *A Winter's Tale* (IV, 4, 224). Evil or poisonous properties of minerals crop up in *Cymbeline* (V, 5, 50) as "a mortal mineral;" and in *Othello* (II, 1, 306) we read, "Doth like a poisonous mineral gnaw my inwards;" although, to be sure, "mineral" was doubtless a more inclusive term then than it is today and bore a broader connotation. In the same play (V, 2, 144), it is a little startling to find chrysolite cited. Bitumen is twice alluded to as a calking compound in *Pericles* (III, 1, 72, and III, 2, 57). Salt apparently was of interest strictly because of its taste and its presence in sea water, not as a mineral.

Shakespeare's list of metals is astonishingly brief. Many passages compare this or that to gold or silver or iron. But actual reference to these as metallic elements is less common. I noted five references to copper, forty-odd to iron, some twenty to lead, twenty-one to silver, nearly two hundred to gold, and but two to mercury (of course called "quicksilver"). It is indeed strange if this is the entire list. Where, for example is tin? Surely, the Cornish mines should have been known to Shakespeare, and, with such alloys as brass and bronze in daily use, it is odd to find tin omitted. If we digress a little from geology, we find some understanding of its allied fields, mining and metallurgy, in *All's Well That Ends Well* (III, 6, 39–40):

> to what metal this counterfeit lump
> Of ore will be melted,

in *Hamlet* (IV, 1, 25–27):

> like some ore
> Among a mineral or metals base,
> Shows itself pure,

and from *Henry IV*, Part I (I, 3, 60–63), I take:

> This villainous salt-petre should be digg'd
> Out of the bowels of the harmless earth,
> Which many-a good tall fellow had destroy'd
> so cowardly.

Further, from *Henry IV*, Part I (III, 1, 168–169), comes the expression "as bountiful as the mines of India," and in *Othello* there is mention of "rough quarries" (I, 3, 141) and "mines of sulphur" (III, 3, 329); *The Tempest* (I, 2, 254–255) supplies the slightly ambiguous phrase "to do me business in the veins of the earth."

Lime and its uses as mortar and cement are often mentioned, as one should expect, for the industry of limestone-burning was already old in England in Elizabethan times, and "the reek of the lime kiln" (*Merry Wives of Windsor*, III, 3, 86) had long offended men's nostrils. There are brief citations of lime or its use in *Coriolanus* (IV, 6, 85); *Henry VI*, Part III (V, 1, 84); *King John* (II, 1, 215–219); *Richard II* (III, 3, 26); and *Midsummer Night's Dream* (V, 1, 162). Mineral or mined coal as distinct from charcoal appears in the well-known line from *Henry IV*, Part II (II, 1, 95–96), "at the round table, by a seacoal fire," and in like words from *The Merry Wives of Windsor* (I, 4, 9–10), whereas in *Much Ado About Nothing* (III, 3, 11) there is introduced the minor character, George Seacole. The implication of the word "seacoal" or "seacole" is that such fuel had been mined at a distance and shipped by sea to London in contradistinction to the locally burned charcoal, which was hauled to the city in carts.

Rocks are neglected more than minerals. To be sure, there are such general terms as "harder than stones," "splitting rocks," and the like, but citations of specific kinds are comparatively rare. Probably the most-mentioned rock (or mineral, if you prefer) is flint, hailed for its hardness and its fire-producing quality. Marble comes in for more than its deserved share of fame, even though we disregard mere comparisons between it and human qualities. Its durability is praised in *Macbeth* (III, 4, 422), and mention made of its solubility in "much rain wears the marble" (*Henry VI*, Part III, III, 2, 49–50). Yet never a line did I find that touches upon granite, sandstone, or slate! Perhaps the nearest approach to any of these is "a freestone-coloured hand" (*As You Like It*, IV, 3, 25) freestone meaning Bath brick, a coarse sandstone. Also in *As You Like It* (I, 2, 57) whetstone is cited, and it occurs again in *Macbeth* (IV, 3, 228) and in *Troilus and Cressida* (V, 2, 75). Touchstone, besides appearing as the name of a character, has its use implied in *Pericles* (II, 2, 37): "gold that's by the touchstone tried." Chalk is occasionally mentioned, usually as the adjective "chalky." It was doubtless known to Shakespeare from its abundance in southern England, where it and flint occur naturally together.

Unconsolidated sediments and soils gain a share of attention. There is "Nilus' slime" in *Antony and Cleopatra* (I, 3, 69), and, in the same play, quicksands (II, 7, 65–66). Ooze is used and recurs in *Cymbeline* (IV, 2, 205–206); *Henry V* (I, 2, 164); *Pericles* (III, 1, 61); *The Tempest* (I, 2, 252–253). Sand or sands are often mentioned and sometimes their special attributes noted: as "one sand [grain] another not more resembles" (*Cymbeline*, V, 5, 120–121); and "sandy bottom'd Severn" (*Henry IV*, Part I, III, 1, 65); "congregated sands" (*Othello*, II, 1, 69); "yellow sands" (*Tempest*, I, 2, 376). Movement of sand is described in *Titus Andronicus* (IV, 1, 104–105) as "the angry northern wind will blow these sands. . . ." Clay, shards, flints, pebbles, mud, marl, all are recorded. I shall mention but two citations on the soil; yet see how appreciation of its value and depletion are suggested in the lines from *Richard II* (III, 4, 38–39):

> The noisome weeds, which without profit suck
> The soil's fertility from wholesome flowers.

And observe also the informative passage from *Henry IV*, Part I (I, 1, 63–65), indicating the recognition of various soil kinds:

> Sir Walter Blunt, new lighted from his horse,
> Stain'd with the variations of each soil
> Betwixt that Holmedon and this seat of ours.

Prior to the mid-eighteenth century, few are the written proofs that men understood the true nature of fossils as evidence of ancient life. Is it then little wonder that Shakespeare has almost nothing to say on this phase of geology? To be sure, amber, which is fossilized tree gum, is mentioned (cf. *ante*). Shakespeare touches upon petrification in *Hamlet* (IV, 7, 20)—"like the spring that turneth wood to stone"—and there is a suggestion of the process in *Troilus and Cressida* (V, 10, 18).

In physiography and physiographic processes, interpreted liberally, Shakespeare's allusions to earth science are abundant and articulate. From *Antony and Cleopatra* (IV, 14, 5–6) we have:

> A pendent rock,
> A forked mountain, or blue promontory.

Plains and mountains are given scant treatment, the mountains more in the geographic than geologic category, including the Alps, Pyrenees, Apennines, Aetna, Olympus, the Taurus, and the Caucasus. Occasionally, there are indications of the characteristics of mountains, their weather, and climates. Of citations on cliffs, the finest is the descriptive passage on Dover Cliffs from *Lear* (IV, 6, 11–22):

Come on, sir; here's the place: stand still. How fearful
And dizzy 'tis to cast one's eyes so low!
The crows and choughs that wing the midway air
Show scarce so gross as beetles: half way down
Hangs one that gathers samphire, a dreadful trade!
Methinks he seems no bigger than his head:
The fishermen that walk upon the beach
Appear like mice; and yond tall anchoring bark
Diminish'd to her cock; her cock, a buoy
Almost too small for sight: the murmuring surge
That on the unnumber'd idle pebbles chafes
Cannot be heard so high.

Turning next to the oceans, there are bits on straits and seas. Remarkable indeed is the comment in *Othello* (III, 3, 453–456) on the movement of the water of the Pontic (i.e., "Black") Sea:

Like the Pontic sea,
Whose icy current and compulsive course
Ne'er feels retiring ebb but keeps due on
To the Propontic and the Hellespont.

If I were to discuss fully the references to ocean water and its behavior, I should be obliged to include a tiresome succession of jottings on tides, particularly their relation to the phases of the moon, "the moist star upon whose influence Neptune's empire stands" (*Hamlet*, I, 1, 118–119). England's varied shores are impressively recognized in *Cymbeline* (III, 1, 18–22):

The natural bravery of your isle, which stands
As Neptune's park, ribbed and paled in
With rocks unscaleable and roaring waters,
With sands that will not bear your enemies' boats,
But suck them up to the topmast.

And, from *Henry V* (III, 1, 12–14), note undercutting by the battering waves:

As fearfully as doth a galled rock
O'erhang and jutty his confounded base,
Swill'd with the wild and wasteful ocean.

By contrast with the last, mark how the poet described, in the sixtieth Sonnet, lines 1–4, the ocean in a gentler mood:

Like as the waves make towards the pebbled shore,
So do our minutes hasten to their end;
Each changing place with that which goes before,
In sequent toil all forewards do contend.

Caves and caverns receive considerable attention, though usually in snatches too brief to warrant quoting. Some of the best are from *Antony and Cleopatra* (V, 2, 355); *As You Like It* (II, 7, 197; and V, 4, 202); *Cymbeline* (III, 3, 38); *Julius Caesar* (II, 1, 80–81); *Henry V* (II, 4, 124); *Henry IV*, Part II (III, 2, 88); *Richard II* (I, 1, 105); *Othello* (I, 3, 140); *Titus Andronicus* (II, 3, 24; III, 1, 271; IV, 2, 179; and V, 2, 35); *Twelfth Night* (IV, 1, 52); and *Two Gentlemen of Verona* (V, 3, 12).

In Shakespeare, as in Isaiah, there may have been an appreciation of denudation and wearing down of the land, illustrated in Sonnet LXIV (5–11):

When I have seen the hungry ocean gain
Advantage on the kingdom of the shore,
And the firm soil win of the watery main
Increasing store with loss and loss with store,
When I have seen such interchange of state,
Or state confounded to decay;
Ruin hath taught me thus to ruminate.

That understanding of the varied behavior of different kinds of rocks exposed to the elements was appreciated may be inferred through contrast of (and I again quote) "much rain wears the marble" (*Henry VI*, Part III, III, 2, 49–50) with "as unrelenting flint to drops of rain" (*Titus Andronicus*, II, 3, 141). Finally, there are those magnificent six lines from *Henry IV*, Part II (III, 1, 46–51), on the wasting away of the land, the interchange of land and sea:

And see the revolution of the times
Make mountains level, and the continent,
Weary of solid firmness, melt itself
Into the sea! And other times, to see
The beachy girdle of the ocean
Too wide for Neptune's hips.

Not to be omitted from among physiographic processes are the effects of running water and the behavior of streams. In *Antony and Cleopatra* (II, 2, 20–26), local color is introduced in:

Thus do they, sir; they take the flow o' the Nile
By certain scales i' the pyramid; they know,
By the height, the lowness, or the mean, if dearth
Or foison follow: the higher Nilus swells,
The more it promises: as it ebbs, the seedsman
Upon the slime and ooze scatters his grain,
And shortly comes to harvest.

Floods from melting mountain snows are touched upon in *Henry V* (III, 5, 50–52):

... the melted snow
Upon the valleys, whose low vassal seat
The Alps doth spit and void his rheum upon.

A receding inundation is described in *King John* (V, 4, 53–57):

Like a bated and retiring flood
Leaving our rankness and irregular course
Stoop low within those bounds we have o'erlook'd
And calmly run on in obedience
Even to our ocean.

Shakespeare mentions springs as now clear, now muddy, warm or cold, fresh or salt, and their effects upon man, either good or evil. By contrast, here are two beautiful lines from *Henry VIII* (I, 1, 154–155):

As clear as founts in July when
We see each grain of gravel,

and, from *Troilus and Cressida* (III, 3, 311–312):

My mind is troubled like a fountain stirr'd
And I myself see not the bottom of it.

The one hundred and fifty-third Sonnet, lines 4–8, lauds spring-water's curative powers:

In a cold valley-fountain of that ground;
Which borrow'd from this holy fire of Love
A dateless lively heat, still to endure,
And grew a seething bath, which yet men prove
Against strange maladies a sovereign cure.

But of all passages on the behavior of running water, these lines from *Henry IV*, Part I (III, 1, 98–114), astonish most because they show appreciation of changes in a meandering stream, means to control its wanderings:

Hot. See how this river comes me cranking in,
And cuts me from the best of all my land
A huge half-moon, a monstrous cantle out.
I'll have the current in this place damm'd up;
And here the smug and silver Trent shall run
In a new channel, fair and evenly;
It shall not wind with such a deep intent,
To rob me of so rich a bottom here.
Glend. Not wind, it shall, it must; you see it doth.
Mort. Yea, but
Mark how he bears his course, and runs me up
With like advantage on the other side,
Gelding the opposed continent as much
As on the other side it takes from you.
Wor. Yea, but a little change will trench him here,
And on this north side win this cape of land;
And then he runs straight and even.

The quiet current, deep and still, is distinguished from the shallow, turbulent stream in "smooth runs the water where the brook is deep" (*Henry VI*, Part II, III, 1, 53) and "shallow rivers, to whose falls" (*Merry Wives of Windsor*, III, 1, 17).

These flashes of geologic color have not been meant to prove that Shakespeare had an extraordinary comprehension of geological processes and phenomena. I have hoped only to demonstrate that in the time of Good Queen Bess there was among Englishmen a considerable knowledge of rocks and minerals, of the ocean and its behavior, and particularly that there was recognition of those larger features and processes we dub physiography. Even in Elizabethan times one might find "books in the running brooks, sermons in stones."

ABSTRACTS FOR THE PRESS

By HERBERT B. NICHOLS

Science Editor, The Christian Science Monitor, *and President, National Association of Science Writers.*

THE job of the science reporter is to bridge that gap between what literate people can reasonably be expected to know, and what the scientist has newly uncovered. No two readers ever have the same background or capability of understanding, so it is not possible to lay down any standard formula of exactly what should be told, or how it should be worded. Every science story has its own individuality, and for every reader it will have a slightly different meaning or point of contact.

What to tell the public and what to omit, involves all the "know-how" of the science reporter. It is his stock in trade as much as the knowledge of how to introduce novelty, interest, and knowledge in proper proportions in the classroom constitutes the stock in trade of the professor. When it comes to making science palatable for the layman, a stock answer popular among Army War College students applies here as well: "It all depends on the situation."

But this isn't much help to the scientist who wants to know exactly what he should do in preparing an abstract for the press. Should an abstract be written in the same manner, say, as one for *Chemical Abstracts* or *Biological Abstracts?*

No.

Such an abstract is, however, better than none at all. It gives the reporter who happened to major in chemistry or biology all he needs to know—perhaps. For the reporter who happened to major in astronomy or geology, the significance of the work may be entirely lost—his background for that particular story is limited or missing. Usually the paper will be thumbed through hurriedly, not touched at all unless a phrase or sentence happens to catch the eye and there's a glimmer of understanding—or there just isn't anything else to choose from that day.

A good rule to follow in writing for the science reporter is to consider him in the same light you would a student who has come to your laboratory for the first time, is interested in what you are doing, but has only a rather vague, general picture of what some of the problems are in your branch of science.

You wouldn't dismiss him with the loose statement: "We are engaged in considering some of the unexplained aspects of tropistic responses among the Compositae." That may be exactly correct, but it leaves so much unsaid that about the most intelligent reply you can expect to hear is, "Oh?"

A generalized sentence is equally unsatisfactory for the press. With 1,500 or more scheduled papers on a program, it is impossible for the reporter to follow up an abstract like that to see whether the work is really significant or not.

It would be much more valuable if the author would go on to say which tropisms were investigated and what the results of the work disclosed. Something of the methods employed, a few words about where the present work fits into the background of known facts concerning tropisms, and perhaps a hint of other problems still in need of study would not be amiss. One of the most successful professors I know never delivers a lecture without pointing out to his students several new avenues in need of research.

The length of the abstract depends upon how closely a subject comes to affecting the public. If the results are of value only

to "pure" science, of interest only because the findings add to our background of knowledge concerning tropisms, the abstract can be written in three or four short paragraphs.

But supposing the chemotropic response upon stimulation with a spray of 2,4-dichlorophenoxyacetic acid indicates that poison ivy and many other noxious weeds go into such spasms of cellular activity that they destroy themselves. There is now a very definite suggestion of a way such weeds can be eradicated, and the reporter would then like to know much more about the methods of study used, whether cytological work was accomplished, whether there is any connection with animal tropisms, how widespread the investigations are. In fact, a quite detailed abstract is called for. If patents have been applied for, or an industrial laboratory has taken an interest in the subject—perhaps started a pilot plant for the manufacture of the chemical—all this should be included in the abstract. It will save the reporter's time, and yours.

Even then, the chances are that the reporter would like to get hold of the whole paper. And he'll probably want an interview, perhaps want to send a photographer out to your laboratory to make some on-the-scene shots.

The fact that the score or so of science reporters and editors who follow scientific conventions around the country, much like sports reporters follow the world series games, all seem to choose the same papers to write about in each session would indicate that there must be some general criterion for making a choice. There is. That factor is "interest" or "possible future value to civilization." Thus, stories of progress in industrial engineering or the applied sciences are more often used than reports from the so-called pure sciences.

In order to qualify as news there must be some point of contact between the subject under investigation and the public. Much depends upon the social meaning or utilitarian value of research, its possibilities after further development by the engineer, the manufacturer, the ultimate consumer; but more often the determining factor in whether a science story makes front page, jump page, zee-whiz box, or round file (where most press-agent copy and free advertising handouts end their little hours) is the amount of human interest the story carries.

The more often an abstract makes the reporter say to himself, "That's interesting, I didn't know that before," the more often a good newspaper story will be printed, and the closer it will be to what the scientist would like to see associated with his name. The longer the technical man can hold the interest of the reporter with his abstract, the less room there will be for editorializing or adding background and side remarks.

Back in the 1920's science writers began the practice of "grading" the papers presented at scientific meetings—not from the standpoint of scientific worth, but as potential newscopy. The practice has not been used so much in recent years because of the chagrin many eminent scientists show when their papers turn up with a "D." "A" is the highest grade, of course, and goes to those reports that have wide public interest, that are well presented, and that have sufficient "quotable quotes" to give them authority and meaning. "B" tells the tardy reporter skimming through the abstracts that here is something pretty good, not front-page copy, but a story that's all there and worth while telegraphing or cabling. A "C" story is one that's technical but significant in its field, requiring considerable additions from the reporter's background of knowledge. A "D" report is one that's hopelessly technical, of interest only to mathematicians or abstract scientists, or perhaps too insignificant to bother with.

Celebrities at a convention—presidents

or directors of large scientific bodies, Nobel prize winners, men and women who have made headlines before—always rate "A" no matter what their abstracts say. If they aren't complete enough, or clear, then delegations from the fourth estate will ask for a complete paper or an interview or both.

In the A.A.A.S. it is frequently difficult for the press to find enough in the abstracts to meet its need. Too many speakers send in no abstract at all, furnish only the title, or write a single sentence intended either to discourage the reporter or cause him to seek out the author. Stories made up of names and filled with titles and generalizations are of small or no value to reporters of large metropolitan dailies. Some scientific organizations, such as the American Chemical Society, will not permit a paper to be listed on the program unless the author makes some attempt to send in a suitable abstract in advance of the meeting.

Secretaries of the various Sections or some other designated officer could perform a great service to the press if they would either confer with Dr. Sidney Negus, the A.A.A.S. press representative, or send in written informal comments—not for publication—concerning which papers in their sections are most significant and which need to be taken with a grain of salt.

But, most important of all, each speaker should mail in *something* by way of an abstract, and do it early.

HEADQUARTERS ASSIGNMENTS

A partial list of headquarters assignments for the Sections and societies that will meet with the A.A.A.S. at Chicago, December 26–31, 1947, is given below. The Sherman Hotel will be the general headquarters for the meeting.

CONGRESS HOTEL
- American Association of Economic Entomologists
- American Microscopical Society
- American Society of Naturalists
- American Society of Parasitologists
- Beta Beta Beta
- Ecological Society of America
- Entomological Society of America
- Phi Sigma Society (Council only)
- Society for the Study of Evolution

PALMER HOUSE
- Sections B* and O
- American Association of Physics Teachers*
- American Dietetic Association
- American Meteorological Society*
- American Physical Society*
- American Society for Horticultural Science
- Honor Society of Phi Kappa Phi
- Philosophy of Science Association
- Pi Lambda Theta
- Potato Association of America
- Sigma Pi Sigma
- Society for Research in Child Development

SHERMAN HOTEL
- Sections A, C, D, E, H, I, K, L, M, Nd, Nm, Np, and Q.
- Academy of World Economics
- American Chemical Society, Chicago Section
- American Nature Study Society
- Cooperative Committee on Science Teaching of A.A.A.S.
- National Association of Biology Teachers
- National Science Teachers Association
- Pi Gamma Mu
- Research Council on Problems of Alcohol
- Sigma Delta Epsilon
- Society of the Sigma Xi

STEVENS HOTEL
- Sections F and G
- American Fern Society
- American Phytopathological Society
- American Society of Plant Physiologists
- American Society of Plant Taxonomists
- American Society of Zoologists
- Botanical Society of America, Inc.
- Genetics Society of America
- Herpetologists League
- Limnological Society of America
- Mycological Society of America
- Sullivant Moss Society

* Meetings will be held on campus of The University of Chicago.

IT'S A DATE

By SAMUEL G. BARTON

Professor Barton (Ph.D., Pennsylvania, 1906) is a member of the Department of Astronomy at the University of Pennsylvania. During World War I, he was Director of the U. S. Shipping Board Navigation School and, during World War II, an instructor in the U. S. Navy Pre-flight School. To readers interested in pursuing the subject of this essay further, Dr. Barton recommends The Calendar, by J. K. Fotheringham, in the British Nautical Almanac, *1931; and* Handbook of Dates for Students of English History. *London: Royal Historical Society, 1945. The latter contains an excellent bibliography on chronology.*

SIR ISAAC NEWTON, the greatest astronomer, and probably the greatest scientist, of all time, was born in Woolsthorpe, England, sometime in the year 1642 or 1643. The date is left thus indefinite because I have found, in what are usually regarded as at least moderately reliable sources of information—biographies, histories, encyclopedias, treatises on astronomy and on physics, and the like—the following given as the date of his birth: January 4, 1642; January 5, 1642; December 5, 1642; December 25, 1642; January 4, 1643; and January 5, 1643.

There is no real uncertainty as to the date of his birth but, even if there were, there should be none about the date of his death, for few men were more famous. His death was world-wide news. Nevertheless, I find given as the date of his death March 21, 1725; March 20, 1726; March 3, 1727; March 20, 1727; March 31, 1727; and May 20, 1727.

It is probably impossible to account for some of these dates except by attributing them to gross carelessness. A likely, or at least possible, explanation can be given for some of them. Some are correct when properly interpreted. The errors show that otherwise well-educated persons need information on the subject of calendars and that a rediscussion of it should be of value.

In such a discussion certain facts must be kept clearly in mind. From the time of the establishment of the Julian calendar, in 45 B. C., until October 1582, this calendar was in general use. In it every fourth year is a leap year. With our present system of numbering years from the supposed year of the birth of Christ (which system, however, was not introduced until A. D. 525 and was little used until the eighth century), the leap years, in the A. D. period, are those years (with the year beginning January 1) whose numbers are evenly divisible by four.

Under the Julian calendar various dates have been used as the beginning of the year, chiefly January 1, March 1, March 25, and December 25. Convincing evidence that Augustus Caesar did not change the number of days in August, as is commonly stated, is given by Lamont in an article on the Roman calendar in *Popular Astronomy*, November 1919. It is to be hoped that the erroneous statement will not be repeated.

Two changes were made in the Julian calendar in 1582, primarily for religious reasons connected with the celebration of Easter. Ten days were dropped from the calendar, the day following October 4 of that year being called October 15. Furthermore, all future century years, all of which would be leap years by the Julian calendar, were to be leap years only if their numbers were evenly divisible by 400. Thus 1600 was a leap year in the new calendar, as in the old, but not 1700, 1800, and 1900. The beginning of the year was definitely set at January 1.

This slightly modified calendar is called the Gregorian calendar. The Julian calen-

dar, however, continued in use in many places. It was used in England and her colonies until 1752; it was retained in Russia until 1918, in Greece and Rumania until 1924, and in Turkey until 1927.

Since these two calendars have been in use simultaneously in different parts of the world, it is frequently necessary to distinguish between them. A date in the Gregorian system is designated as New Style (N.S.), and one in the Julian system as Old Style (O.S.). This distinction should always be made where there can be reasonable doubt, but, unfortunately, it is not, and sometimes the terms New and Old Style are used in a different sense. Dates of events between 1582 and 1752, in England and America, are particularly capable of misinterpretation when not so designated.

With these facts in mind, we can discuss the discrepancies in the dates relating to Newton and trace the sources of confusion. Newton was born December 25, 1642, by the Julian calendar, the one then in use in England, his native country. He was born January 4, 1643, by the Gregorian calendar —a different month, a different day, a different year. The difference between the two calendars was then still 10 days.

Wolf, apparently using a difference of 11 days instead of 10, states in his *Geschichte der Astronomie* that Newton was born in "Whoolstorpe," January 5, 1643. This misinformation, including the misspelling of Woolsthorpe, was evidently copied in *La Grande Encyclopédie* and in Newcomb-Engelmann's *Populäre Astronomie* (7th ed., p. 811). (There is a similar error in the date of the death of Tycho Brahe.) Dessauer, in his life of Newton (p. 400), makes the same mistake in the date. The day was Christmas Day in England, but not where the Gregorian calendar was in use. It was Thursday, however, everywhere, as the succession of weekdays was not disturbed by the change in the calendar.

If the year was considered as beginning on March 1 or on March 25, with an otherwise Gregorian date, as was sometimes done, Hazeltine's date,[1] January 4, 1642, is not impossible, but doubtless she simply erred in a curious way. Dessauer's discussion (p. 399) shows some such reasoning in obtaining his date, January 5, 1642. The date December 5, 1642, is presumably intended to be December 25, 1642. It is given in Winkler Prins, *Algemeene Encyclopaedia*.

Newton died March 20, 1727, by the Julian calendar, with the year beginning January 1. With the year beginning March 25, the date would be March 20, 1726, as given in *La Grande Encyclopédie*. By the Gregorian calendar the date was March 31, 1727. At this time the difference between the two calendars was 11 days, since the year 1700 was not a leap year in the Gregorian calendar. It is not hard to believe that March 3, 1727, the date of death given by Berry in *A Short History of Astronomy* (p. 241), is a misprint for March 31, 1727, and that May 20, 1727, given in *Enciclopedia Universal Ilustrada* is a misprint for Mar. 20, 1727. The date March 21, 1725, given in Winkler Prins, is a mystery.

It is commonly said that Newton was born in the same year that Galileo died. Galileo died January 8, 1642, Gregorian calendar, but in that system Newton was born January 4, 1643, which is not in the same year numerically, although the two events were less than a year apart. Galileo's death occurred December 29, 1641, in the Julian calendar, which again is not the year of Newton's birth.

In England, in early times, the year began December 25, but from late in the twelfth century the legal year began March 25, and the same was true in English colonies. March 25 commemorates the announcement to Mary that Christ would be born (Luke 1:26–38), just as Christmas commemorates His birth. March 25 is the day of the Feast

of the Annunciation and is commonly known as Lady Day. January 1, however, was customarily called New Year's Day, and New Year's gifts were presented to the kings and queens at this time.

Thus, for all dates between January 1 and March 24, inclusive, there is uncertainty as to the year number to be associated with the Julian date. This uncertainty is increased by the fact that March 25 was not used as the beginning of the year in Scotland, and that it was used at various times in countries other than England and her colonies. This uncertainty was usually removed, especially in later times, by writing a double date. Thus, the record in the family Bible states of George Washington[2] that he "was born yᵉ 11th Day of February 1731/2 about 10 in the morning." This indicates that the year of his birth was 1731 for those who began their years with March 25, and 1732 for those beginning the year with January 1.

But suppose that only one year number is given for such a date—how is the date then to be interpreted? For instance, on the tablet concerning Newton in Westminster Abbey, we find the inscription[3] "*Obiit xx Mar. MDCCXXVII;*" that is, he died on the twentieth of March, 1727. Our previous discussion shows that this is the date if the year began January 1. Are we safe then in assuming that other such dates should be interpreted in this manner? On the monument to Queen Elizabeth in the Abbey we find the inscription[4] "*Obiit 24 Martii, Anno Salutis MDCII;*" that is, she died on the twenty-fourth of March, in the Year of Salvation 1602. We know that she died March 24, 1602/3, so this inscription uses March 25 as the beginning of the year.

Although Newton usually dated his letters properly, that is, without this ambiguity, he was not entirely consistent, for we find a letter to Halley[5] dated "Feb. 18, 1686," meaning "1686/7;" another, to Dr. Mill,[6] is dated "Jan. 29, 1694," meaning "1693/4." Francis Bacon consistently used years beginning March 25 without the use of double dates. Newton dated one of his letters[7]

$$\text{Jan. 11th, } 8\,\frac{7}{8}$$

and received one from his nephew Humphrey Newton dated in the rather curious manner,[8]

$$\text{January 17, —}2\,\frac{7}{8}.$$

The century number, 16, being supposed obvious, is omitted in the first case, and 17 is replaced by the dash in the second, just as we might write a date as July 4, 47, or, better, July 4, '47. The latter part of the date might have been written 87/8 or 87–8.

Newton wrote one date as "March 2, 1674 O. S."[9] where Old Style is used to indicate years beginning March 25, and not a date in the Julian rather than in the Gregorian system—its usual significance. Instead of using O.S. or N.S., frequently both dates are given in a combined form. Thus Leibnitz, residing in Germany, where the Gregorian calendar was in use, writing to Newton, in England, where the Julian was in use, dated his letter[10]

$$\frac{7}{17}\text{ March, 1693,}$$

the upper being the Julian date. This might possibly be misinterpreted in England. At any rate, Flamsteed is more specific in writing his date[11] as "Feb. 17–27, 1680–1." A similar but more complex date written in this style is

$$\frac{28}{9}\text{ day of }\frac{\text{November}}{\text{December}}\text{ 1713,}$$

and the still more complex date of Newton's birth is

$$\frac{25}{4}\;\frac{\text{December}}{\text{January}}\;\frac{1642.}{1643}$$

It is now customary to give the year of a Julian date of a historic event as though the year began January 1, regardless of the practice at the time and place of the event. Such a date is called the historical date; but of

course there are authors who are either careless or ignorant, and care is needed to be sure that the dates in the original sources are correctly interpreted.

The decree of Pope Gregory XIII ordering the adoption of the Gregorian calendar is "dated at Tusculum in the year of the Incarnation of our Lord one thousand five hundred and eighty first, the sixth of the calends of March, of our pontificate the year 10." The equivalent of this date is February 24, 1581, Julian calendar of course. The Pope, however, did not begin his years with January 1, so the historical date is February 24, 1582, and that is the date that would normally be given. Similarly, by the original record, Marco Polo died January 8, 1323, but since in Venice the years then began March 1, not January 1, the historical date is January 8, 1324.

Julius Caesar is commonly supposed to have made January 1 the beginning of the year. Beginning about the seventh century, the church preferred to begin the year with one of its festivals, such as Christmas Day, Lady Day, or Easter Day. In the Middle Ages, in certain religious or ecclesiastical connections, March was considered to be the first month of the year, and certain computations were based upon March 1 as the beginning of the year. This day was so used, however, for these special purposes only and was not in general use, although there were a few places where the year numbers changed on March 1, notably at Venice. In the later centuries of the Middle Ages, January 1 gradually came into greater favor, and it was definitely made the beginning of the year in the Gregorian calendar in 1582.

It is of particular interest to note that the Quakers, in England and America, and perhaps elsewhere, until 1752 called March the "First Month" and designated the others correspondingly, February being to them "Twelfth Month." Franklin, in *Poor Richard's Almanacks* (famous in their day and still so), used years numbered as beginning January 1, but the month itself was designated as "XI Mon. January;" that is, Franklin, too, designated January as the "Eleventh Month," and he continued to do so until 1752. There are other very interesting points about the Quaker calendar, which I shall not discuss here.

As already stated, March 25, Lady Day, was commonly used as the beginning of the year. When, in 1744, Easter Day coincided with Lady Day, Franklin's *Almanack* designates the day as "Easter Day in my Lady's lap." Queen Elizabeth died on March 24. Her contemporaries termed this day "Lady's Eve" and "Our Lady Even," just as we speak of New Year's Eve.

The *Encyclopaedia Britannica*, under the heading "New Year's Day," gives the following misinformation: "The first day of the year. In the Gregorian calendar this occurs 12 days earlier than in the Julian; thus New Year's Day is the English 13th of January." The intended meaning of the preceding sentence is not clear. The facts are that the difference between the dates in the two calendars has been 13 days since 1900 and that the Julian New Year's Day now falls on January 14 of the Gregorian calendar.

Notwithstanding the different days for beginning the year, February 29, the extra day inserted in leap years, was the same day. Thus, although Washington was born in 1731, counting March 25 as the beginning of the year, February 29 was inserted in that year, even though 1731 is not evenly divisible by four. Jefferson's father was born[12] February 29, 1707–8.

THE dates of events in English history are expressed in the Julian calendar, that is, as Old Style dates, until 1752. The custom in the United States differs in that we frequently express the dates of events in

our history between 1582 and 1752 in the Gregorian calendar, that is, in the New Style. We did not have the large number of important historical events in this interval that England had, and it is perhaps simpler to have these dates expressed in the system now used, thus having a single system. This is debatable, however.

To illustrate, both in the United States and in England, Columbus would be said to have discovered America on October 12, 1492, just as Columbus himself recorded the date; but many of us, at least, say that the Pilgrims landed at Plymouth on December 21, 1620, although they recorded the date as December 11, 1620, and the English would so date events on that day. The English will tell you that the Astronomer Royal Maskelyne was born October 6, 1732. Had he been born in this country we would change the date to the Gregorian system, as we do with the date of Washington's birth in the same year, and say that he was born October 17, 1732. There is the greater reason for doing this when the person concerned was alive in 1752, when the calendar was changed. We would not transform the dates of English history in this manner.

There is an enormous amount of inconsistency in the matter. Historians and others dealing with dates frequently, if not usually, give dates in this interval without the slightest indication as to whether they are Julian or Gregorian, and if one is determined to find out which by hunting through the original sources—a thing he should not be obliged to do—he finds it difficult to locate them. Often some dates are given by an author in one system and some in the other without distinction. Some dodge the point by giving the year only.

Suppose that we are treating of William Penn, who was born in England and who died there, but who lived for a time in Pennsylvania and was very important in its history—how shall we date his life? Both the *Encyclopaedia Britannica* and the *New International Encyclopedia* state that he was born October 14, 1644, and that he died May 30, 1718, without stating which system of dating is used. It is Old Style; but the fact is that he died July 30 and not May 30, 1718. This error evidently resulted from a misinterpretation of the expression "Fifth Month."

The same ideas prevail in the times of the celebration of anniversaries of historic events. For dates prior to 1582 the original date is used. Thus, Columbus Day, which commemorates the discovery of America, is October 12. Christmas Day, the anniversary of the birth of Christ, was celebrated on the same date, December 25, the supposed true date of the event, in both the Julian and the Gregorian calendars, although this was not actually the same day.

However, when the four hundredth anniversary of the discovery of America was celebrated by the World's Columbian Exposition, the grounds were formally dedicated "On Oct. 21, 1892—corresponding to Oct. 12, 1492" (*Encyclopaedia Britannica*, 5, 145). Here the Gregorian system was applied by extrapolation to a date prior to its creation—an unusual procedure.

For events in the history of the United States later than 1582, we in the United States usually celebrate on the Gregorian date, even though the Julian calendar was in use at the time and place of the event. As examples we have William Penn's birthday (Pennsylvania Day, in Pennsylvania) on October 24, not October 14; Franklin's birthday (Poor Richard Day), January 17, not January 6; Washington's Birthday, February 22, not February 11. Georgia Day is February 12, not February 1, when Oglethorpe landed, in 1733.

Note, however, that Forefathers' Day, which commemorates the landing of the

Pilgrims, is December 22, although they landed on December 21, 1620, which is December 11, 1620, O.S. The explanation is that the Old Colony Club started the celebration of the day in 1769, which was shortly after the adoption of the Gregorian calendar. Eleven days were added to the Julian date, which was the correct difference in 1769 but not in 1620. The erroneous day for celebration has been used ever since. No one pointed out the error until 1832.

The custom in England is different. There events are commemorated in the Gregorian system on the same date as that on which they occurred in the Julian. Thus the bicentenary of the death of Newton was considered to be March 20, 1927, and not March 31, 1927, as we would have considered it. The main features of the celebration were on March 19, since the twentieth fell on Sunday. Sir Christopher Wren died February 26, 1723, O.S. A bicentenary service was held February 26, 1923. When the event is one of English history such as these, we in the United States are likely to conform to the English system, although I suppose that there is no rigid rule.

Tycho Brahe was born December 14, 1546, between nine and ten o'clock in the morning, as we state the fact. Tycho himself, however, in several places[18] alludes to December 13 as his birthday. The reason is that Tycho used astronomical time, in which the days begin at noon rather than at midnight. As this system was not used by the general public, I shall explain further.

The bill to improve the calendar introduced in the House of Representatives by Representative Kee (H. R. 1345) states that the Gregorian change "entailed a loss of two Fridays, two Saturdays, and two Sundays, and one Monday, Tuesday, Wednesday, and Thursday; or one week and three days of that year." This is an erroneous statement. In the change, Thursday, October 4, 1582, was followed by Friday, October 5, Julian, and by Friday, October 15, Gregorian. The dates October 5–14, inclusive, were dropped, but the succession of weekdays was retained. The combined year 1582, Julian and Gregorian, contained but 365 days, and the weekdays lost were those corresponding to December 22–31, Julian, which went into the year 1583, Gregorian. December 22 was Saturday, so the loss was two Saturdays, etc., and not the days with the names of October 5–14, Julian, given in the bill.

Although all the confusion that has just been discussed and illustrated does not arise from the so-called Gregorian reform of the calendar, I think that the reader should by this time be softened up enough, to use the military expression, to appreciate the background giving rise to the following comment on this change by Newcomb, the greatest astronomer America has produced. In his book *Popular Astronomy* (New York: American Book Co., p. 50), he says:

> If there were any object in having the calendar and astronomical years in exact coincidence, the Gregorian year would be accurate enough for all practical purposes during many centuries. In fact, however, it is difficult to show what practical object is to be attained by seeking for any such coincidence. It is important that seed-time and harvest, shall occur at the same time through several successive generations: but it is not of the slightest importance that they should occur at the same time now that they did 5000 years ago, nor would it cause any difficulty to our descendents of 5000 years hence if the equinox should occur in the middle of February, as would be the case should the Julian calendar have been continued.
>
> The change met with much popular opposition and it may hereafter be conceded that in this instance the common sense of the people was more nearly right than the wisdom of the learned. An additional complication was introduced into the reckoning of time without any other real object than that of making Easter come out at the right time.

Another complication is introduced by the Gregorian calendar. It is a common statement that the length of the saros, the

eclipse cycle, is 18 years, $11\frac{1}{3}$ days, or 18 years, $10\frac{1}{3}$ days, according as four or five leap years are included in the interval. The fact that, by the Gregorian calendar, at times only three leap years are included is usually overlooked or at least not stated. A better statement is that the saros is equal to 18 calendar years plus $10\frac{1}{3}$ days if five leap days (February 29) are included, $11\frac{1}{3}$ days if but four are included, and $12\frac{1}{3}$ days if but three are included, as may happen when a century year not a leap year, such as 1900, is involved. The saroses including the years 1582 or 1752 require special consideration.

As those who read about the reasons for the Gregorian change usually, I think, get a much exaggerated idea of the importance of the fact that the Julian year is a bit too long, thus causing the seasons to come one day earlier in an interval of 128 years, I amplify Newcomb's statement by calling attention to the fact that one may travel by air from the middle latitudes of the Northern Hemisphere to those of the Southern Hemisphere in a few days and by so doing completely reverse the seasons. Even more to the point are the facts brought out in an article in *The Sky* (March 1939), "The Vagaries of the Seasons," by Dr. E. W. Woolard.

Dr. Woolard shows, in particular, that in the United States the number of days intervening between the day of the summer solstice and the average day of highest normal temperature, the lag of the season, varies from 10 days at El Paso, Texas, to 100 days at San Francisco, Calif. At Sacramento, less than 100 miles inland, the interval is but 37 days. Thus there is a difference of 63 days in the times of the hottest day at San Francisco and at Sacramento, which are no great distance apart. Any place may have a late or early spring or other season, in any year.

While on this subject, how can I neglect mention of Phileas Fogg, who, according to Jules Verne, wagered that he could make the tour of the world in eighty days? Having started at 8:45 P. M., Wednesday, October 2, he was due to return before 8:45 P. M., Saturday, December 21. He arrived in London at 8:50 P. M., Saturday, December 21, only five minutes too late, financially ruined, as he supposed.

The next day, nevertheless, faithful Aouda asks, "Will you have me for your wife?" (It was in the year 1872, a leap year.) He replies, "Yes . . . Will it be for to-morrow, Monday?" She agrees, "Yes, for to-morrow, Monday." (In this day she would have replied, "O. K. It's a date.") But the clergyman decided that marriage "tomorrow" was impossible as that day was Sunday. An error in Mr. Fogg's date was thus discovered. There was a mad rush to the starting point, The Reform Club, and the journey was completed within the time limit by the narrowest of margins. Mr. Fogg had traveled around the world eastward but, extremely meticulous though he was, had failed to drop a day from his dates on crossing the international date line. Considering that hectic journey, one can scarcely blame him.

REFERENCES

1. HAZELTINE, MARY E. *Anniversaries and Holidays*, 4.
2. WILSON, W. *Life of Washington*, 41.
3. BREWSTER, D. *Memoirs of Newton*, 2, 394.
4. NICHOLS, J. *Progresses of Queen Elizabeth*, 3, 650.
5. BREWSTER, D. *Memoirs of Newton*, 1, 455, 475.
6. ———. *ibid.*, 2, 141.
7. ———. *ibid.*, 2, 548.
8. ———. *ibid.*, 2, 95.
9. MORE, L. T. *Isaac Newton*, 170.
10. BREWSTER, D. *Memoirs of Newton*, 2, 120.
11. BAILY, F. *Life of Flamsteed*, 123.
12. JEFFERSON, T. *Writings*, 1, 1.
13. DREYER, J. *Tycho Brahe*, 12.

THE ROYAL SOCIETY AND AMERICAN SCHOLARS

By MARGARET DENNY

Miss Denny (M.A., Smith), Assistant Professor of English at the University of Rochester, is interested in the history of ideas, particularly the impact of scientific ideas and practice upon certain representative seventeenth- and eighteenth-century Americans. Her article on the influence of the Royal Society in America from 1663 to 1800 is based on a paper presented at a meeting of the Modern Language Association in Washington.

THERE is general agreement that the Royal Society of London exerted a profound influence upon Americans during the colonial period. There is reason to believe, also, that the Society's influence did not terminate with the American Revolution, since it is obvious that the first two independent scientific societies in this country, the American Philosophical Society, at Philadelphia, and the American Academy of Arts and Sciences, at Boston—both recipients of state charters in 1780—bear marked resemblances to the Royal Society in plan of organization, procedure, and scientific objectives. This imitation of the English organization indicates that colonial Americans had been impressed by the successful methods employed by the Royal Society in propagandizing scientific doctrine and in recruiting scientific practitioners.

During the first half-century of our national history, the scientific temper among Americans became more vigorous and pervasive. Not only was there an astonishing increase in activity among scientists, but the general public came to see science as a way of life and to discover that scientific methods were applicable to a wide variety of human pursuits. The part played by the American scientific society in this education of Americans was probably not unlike that of the Royal Society in England, which, in the seventeenth and eighteenth centuries, had been most successful in the development of many English "virtuosi." Once these amateurs perceived science as a medium for the "relief of man's estate," they were tireless cooperators with the Society in its efforts to improve natural philosophy.

What, first of all, were the principal methods used by the Royal Society for teaching and guiding its natural philosophers? Why were such means considered effective by the Americans who chose to follow the London plan? Obviously, the success of the Society's methods should be reflected in the reactions of those colonial Americans who had come under the Society's influence. In order to obtain answers to these questions, I have arbitrarily selected material that I believe will most clearly reveal this interaction of Royal Society and American scientists.

The fourteen colonial Americans chosen for particular study were:

Governor John Winthrop, Connecticut, an original Fellow	(F.R.S., 1663)
William Byrd, Esq., Virginia	(F.R.S., 1696)
Governor William Burnet, New York, New Jersey, and Massachusetts	(F.R.S., 1706)
The Reverend Cotton Mather, Massachusetts	(F.R.S., Council vote, 1713; Assembly vote, 1723)
Judge Paul Dudley, Massachusetts	(F.R.S., 1721)
Dr. Thomas Robie, Massachusetts	(F.R.S., 1725)
Dr. Zabdiel Boylston, Massachusetts	(F.R.S., 1726)
John Winthrop, Esq., Connecticut	(F.R.S., 1734)
Dr. John Mitchell, Virginia	(F.R.S., 1748)
Governor Francis Fauquier, Virginia	(F.R.S., 1756)
Benjamin Franklin, Pennsylvania	(F.R.S., 1756)
Professor John Winthrop, Massachusetts (Hollis Professor of Astronomy and Natural Philosophy, Harvard)	(F.R.S., 1766)
Dr. Arthur Lee, Virginia	(F.R.S., 1766)
Dr. Alexander Garden, S. Carolina	(F.R.S., 1773)

Because all these men had been elected

Fellows of the Royal Society, I could believe that the Society had successfully brought them into its orbit. There were, of course, more than fourteen Americans who belonged to the Society during the colonial period (see the complete list compiled by R. P. Stearns, *William and Mary Quarterly*, April 1946), but the men I have chosen differ from the other Fellows in that their contributions were printed in *Philosophical Transactions*. Assuming that publication in the *Transactions* was a mark of the Society's approval, I believe that a study of the American Fellows' choice of subject and treatment of material will throw light on the program of work that was being currently recommended by the Society, as well as suggest the effect this program was having on American scientific activity. The *Transactions* printed not more than three papers contributed by most of these American Fellows. In contrast there are the ten communications by Professor Winthrop and by Franklin and the twelve papers by Judge Dudley.

Even at the risk of superficial treatment and repetition of facts already well known, I have chosen to view the scientific activity of the fourteen men as a whole. I have tried to see in perspective the century between Governor Winthrop's first publication in 1670 and the account by Alexander Garden that appeared in 1777. Points of kinship have been sought, and the leading tendencies in eighteenth-century science observed.

IT IS to the credit of the Royal Society that from the outset of its organized activity it assumed the role of educator, for certainly the progress of science was contingent on mass education in the scientific method. In general, only a few points were given special emphasis, but these were repeated over and over again. Many were the echoes of Francis Bacon's words: "We must lead men to the particulars themselves and their series and order." The end pursued by the Society, like that of Bacon's Salomon's House, was "the knowledge of causes and the secret motions of things; and the enlarging of the human empire, to the effecting of all things possible."

By means of the three-hour discussions and demonstrations at the weekly London meetings of the Society, the correspondence and conversations of individual Fellows, and the selected papers that appeared in *Philosophical Transactions*, the Society propagandized scientific method and terminology. In the *Transactions* the work of fact gathering was always called a "relation" or an "account" or a "history." To describe another type of scientific research the words uniformly used were "observations," "causes," "hypotheses," "thoughts," or "suppositions." Constant repetition of terms and multiple papers exemplifying each phase of the scientific method—these comprised the Society's mode of indoctrination.

This educational influence, however, needed to be supplemented by one more direct and dynamic. If scientists could be induced to work cooperatively upon a common problem, they would prove that in truth "many hands make light work." Only experience would convince the worker that in science the policy "what's yours is mine" was not only a good but an essential one. The machinery of the Society's organization was designed, therefore, to make sure that the Fellows worked cooperatively and that their scientific finds were pooled. Among the many devices for stimulating cooperative work on specific problems were the recommendations that came from the eight standing committees created in 1664. The Society assumed the responsibility of keeping each Fellow informed—by way of the *Transactions* if he lived far from London—of the various studies that merited his cooperation. The

Fellow, in turn, promised "to promote the good of the Society;" in practice this meant that he would become conversant with the program of scientific work then being sponsored by the Society and that he would make every possible contribution to that program.

In addition, the Society functioned as custodian of the treasures of the museum and of the papers deposited in the archives. Respect was due these archives because they made it possible for the individual scientist to make use of the discoveries and reports of his colleagues. Many depositors in this international bank of scientific data were needed, and of this the Society's Fellows appear to have been aware. Benjamin Franklin interpreted his election to membership as obliging him to send in that portion of his private correspondence that had reference to the Society's current projects. For a number of months following his election in April 1756, Franklin's exchanges of letters with James Bowdoin, of Massachusetts, and with Cadwallader Colden, of New York, as well as letters from other Americans, were read at the meetings of the Society in London.

How assiduously the Society collected material for its archives may be surmised from the circumstances that led to the election of the two Bostonians William Brattle and John Leverett in 1714. The Society wanted the scientific papers of the late Thomas Brattle, of Cambridge; these were intended to supplement the account of eclipses that had appeared in the *Transactions* of 1704 and 1707. It is probable that Isaac Newton's reference in his second edition of the *Principia* to Brattle's observations of the 1680 comet prompted the Society's interest in the work of the American astronomer. The task of obtaining the papers from William Brattle, his brother's heir, fell to the secretary of the Society. For advice on strategy he turned to Henry Newman, who while at Harvard had assisted Brattle in his observations. Newman suggested the gift of membership to Brattle; and, because Newman must have been familiar with the Damon-Pythias relationship between William Brattle and John Leverett, the election of the latter was also recommended.

The journal-book of the Society reports that Leverett accepted the honor but that Brattle declined it on the ground that he was "unqualified." This appears curious to the twentieth-century observer. Both Brattle and Leverett had long been champions of the new science; they had both done yeoman service for natural philosophy at Harvard College. To an eighteenth-century scholar, familiar with the responsibilities of membership in the Royal Society, however, the behavior of Leverett and Brattle would be proper and consistent. In 1714 Leverett, as President of Harvard College, could "promote the good of the Society" by fostering the scientific spirit at that institution. But Brattle was no longer a tutor at Harvard and could not join Leverett in this indirect service to the Society. When he refused the title of Fellow he served notice that he did not intend to become a co-worker with the Society, did not intend, in short, to do more than deposit his brother's papers in the archives of the Society.

Both early and late colonial Fellows showed that they understood their election committed them to a contract with the Society quite as much as it conferred on them a signal honor. Upon receiving news of his election in 1713, Cotton Mather assured the Society's secretary of his "firm resolution to have annually as long as [he might] live, contributed unto its Treasures." In reply to a letter from an English friend, which described Alexander Garden's election into the Society, the new American Fellow wrote:

> I do not know the usual mode or form of thanking them... please to inform me of the common

method followed on such occasions. This, at least, you may assure them of; my earnest endeavours to serve them in any thing I can, and to promote their plan in every way in my power.

Because the newly elected Fellow could believe he had entered into a covenant with the Society, he naturally might look on the first paper submitted after his election as a pledge of his good faith. Garden bemoaned the inadequacy of this paper. He had attempted, while recovering from a severe fever, to describe and analyze his five electric eels from Surinam, and he greatly feared that he "was little able either to examine these fish accurately, or to digest what few trials [he] could make of their properties." Had Garden been less hasty in sending off his account, he might have made good use of a pertinent article "On the electrical power of the Torpedo" in the *Transactions* that soon came to hand. Professor Winthrop presented his *Thoughts on Comets* (1767) "to the most illustrious Royal Society on account of the great honor" recently conferred on him. His paper was written in Latin, a practice frowned upon by the Society. But I fancy the members were loathe to chide a Fellow whose work had such a gratifyingly solemn tone of dedication. Besides, Winthrop's paper, both in method and material, was precisely the type the Society most desired at that time.

To the new Fellow, his "election paper" might be unique, but to the Society it was usually only one in a series of papers already received from the scientist. Some Americans, on the other hand, sent in material to London, answered the inquiries of Fellows of the Society, and even had articles printed in the *Transactions*, but never received the Society's reward of membership. Students wishing to uncover reasons why the names of certain Americans do not appear on the Society's list of members might well keep in mind the following regulations of the Society: First, the eighteenth-century American had to be recommended by three Fellows instead of the single sponsor required in the preceding century; second, the candidate's name could not appear on the list of Fellows until he had made a sworn statement that he would work for the good of the Society. Those "signing the obligation" (as it was termed) were, after 1753, charged a fee of twenty-one guineas; an additional ten guineas was required of Fellows elected after 1766. Finally, both the Council and the General Assembly had to agree that the candidate would be "useful to the Society." Peter Collinson, because he corresponded with so many American scientists, was the member of the Society best fitted to sponsor their candidacy. Was he negligent? Perhaps Collinson's correspondents were not doing work on which the Society's attention was focused at that time. A correlative study of Collinson's papers and the Society's journal-book might be illuminating.

A great deal of publicity was given to Franklin's election. This may have arisen from the unconventional nature of the circumstances. Franklin was surprised by the Society's action because, so he said, "It was not usual . . . to choose persons into the Royal Society, who had not requested to be admitted." The tone of the entry in the Society's journal-book suggests that it was equally unusual for the members to vote that "the Name of Mr. Benjamin Franklin . . . be inserted in the Lists before his Admission and without any Fee, or any other payment to the Society." Obviously, the procedure concerning election into the Society was well established, and general knowledge of it abroad could be assumed.

Important elements in the pattern of behavior proper for the Society and the candidate may be deduced from the correspondence of Alexander Garden with the English Fellow John Ellis. The negotiation

began with the candidate's expression of interest in membership. Thereafter, however, the initiative became the English Fellow's. Believing that the scientist's cooperative spirit, his interest, and energy, would make him a "useful and valuable member" of the Society, the English Fellow first outlined to him the responsibilities of membership, both scientific and monetary, and then inquired whether these terms were agreeable to him. Upon receipt of an affirmative answer, the Fellow then reported that his candidate wished to become a member. Thereupon the Fellow and two other sponsors composed the certificate of recommendation describing the candidate's qualifications, and the voting in of the new member followed with little or no delay.

Whatever may have been the negotiations preceding Zabdiel Boylston's election in 1726, they must have seemed dull indeed in comparison with the events of five years before, when Dr. Boylston was proving his worth to humanity and to science during the memorable epidemic of smallpox in Boston. It is ironical that Cotton Mather had to borrow from Dr. Douglass, the inveterate foe of inoculation, the volume of the *Transactions* containing the description of the method of inoculation used in Constantinople. Dr. Douglass refused to permit publication of the two reports of the method, and Mather perforce had to make abridgments; these Dr. Boylston had printed in the Boston papers. At length the epidemic was brought under control, and science thereby won a stunning victory over prejudice. In the year following the furor at Boston the Royal Society received from that city an account of the "way of proceeding in the smallpox inoculated in New England." When this famous inoculator was made a Fellow in 1726, the London members had every reason to consider that Dr. Boylston would be a "useful and valuable" member of the Society.

How decisively the Society's current program dominated the scientific investigation of the early American colonial Fellows is immediately apparent. That program was the compilation of a mammoth natural history. Historical data concerning all places and all subjects were first to be collected by means of the cooperative efforts of as many people as possible, and then that material was to be stored in the archives of the Society—"laid up [said the Society's curator, Robert Hooke] only in Heaps as it were, as in a Granary or Store-House; from thence afterward to be transcribed, fitted, ordered and rang'd and tabled . . . to be made fit for use." That a definitive history of the various countries of the world was a major project of the Society is indicated by the heading of the index to the first volume of *Philosophical Transactions:* "A Natural History of all Countries and Places is the foundation for solid philosophy."

The Society made the work of its many cooperators much easier and more efficient by supplying instruction as to the historical data desired. These directions, according to Hooke, were phrased as queries "so as any that shall have an Opportunity and willing to promote this Design may accordingly [choose] the things . . . most likely to be instructive for the discovering of the true Nature of that which he inquires into." In 1661 the Society created a special committee to compile inquiries for historians in distant lands; Robert Boyle's model outline was published in the *Transactions*' initial volume and was called "General heads for a natural history of a country, great or small."

In the early days the Society relied upon its colonial Fellows to act as foreign correspondents, who, by frequent communication with the Society's Secretary or with active Fellows, would keep abreast of the Society's activities; it was also hoped that they would recruit cooperators in their

special districts and would lend a hand if the Society sent out natural historians to gather material. In the seventeenth century Governor Winthrop, in Connecticut, and William Byrd, in Virginia, seem to have functioned as foreign correspondents of the Society to some degree. Both also sent in accounts of American natural history, and in 1694 Byrd carried to England a female opossum, which was duly dissected and reported upon by the English Fellow Edward Tyson.

It was quite natural that during this history-making period any man who showed a willingness to gather and accurately report facts would receive the Society's encouragement, and if his quantity of output—either potential or already contributed—were great enough, he usually was made a Fellow. Cotton Mather was so cooperative and industrious in work for the English Fellows Woodward and Petiver that he was soon recommended for membership, and he remained true to his promise to make annual contributions to the archives in London. Mather, in turn, persuaded John Winthrop, Esq., of Connecticut, to collect fossils for Woodward. In 1734 Winthrop was the donor of what "constituted for its time the largest single gift presented to the Society." The *Philosophical Transactions* of 1738 was dedicated to Winthrop, and in the preface the Society's thanks were expressed for the grand total of six hundred specimens Winthrop had deposited in the museum of the Society.

From 1713 until his death, another New Englander, Thomas Robie, was identified with the monumental collection of meteorological data that the English scientist William Derham was directing.

Of the group of New Englanders who were Fellows of the Society in the early eighteenth century only Paul Dudley does not appear to have begun his work for the Society as the satellite of some English Fellow who was a projector of a large history collection. Dudley set to work on a history of his own—a proposed history of the American Indian, which was almost certainly inspired by his reading of a paper in the *Transactions*.

There was another type of data collection strongly encouraged by the Society, which only the virtuoso with some technical skill could undertake. From Volume IV to Volume L (1669–1758) the *Philosophical Transactions* contained articles that were grouped in the index under the title "Attempts at the discovery of the longitudes of places." Men living overseas who were adept at astronomical observation could make valuable contributions to the cause of science by sending to London their accounts of eclipses. A comparison of their calculations with those of London observers made possible a more exact determination of longitude. An English Fellow, James Hodgson, compared his 1703 observations with those of Thomas Brattle and reported in the *Transactions* his estimate of the longitude of Cambridge. Because Governor William Burnet, of New York, sent in his observations of the eclipses of the first satellite of Jupiter in 1724 and 1725, the London observer, Astronomer Royal James Bradley, was able to determine the longitude of the fort of New York.

The Society's program of data collection dominated the work of the early American Fellows, and it influenced to some degree the work of later colonial scientists. Governor Fauquier, of Virginia, described "an extraordinary storm of hail" that occurred in 1758. Professor Winthrop submitted an account of the earthquake of 1755, taking care to follow the same pattern of presentation used in Paul Dudley's paper, which had appeared in the *Transactions* of 1735. When the Society was collecting meteorological data for the year 1760, conditions in New England were reported by Winthrop. His observation of the transit of Mercury

in 1743, he believed, would "determine the longitude of Cambridge, New England, with more exactness than any of the observations that have been used for that purpose." In addition to a full description of the electric eel, Alexander Garden cheerfully gathered data for such London Fellows as Stephen Hales, John Ellis, Henry Baker, and Thomas Pennant. In one of John Mitchell's papers he presented first a historical account of other methods of manufacturing potash before describing the improved method he strongly recommended.

In general, however, the contributions sent in by American Fellows late in the colonial period differed markedly from earlier ones. It is noticeable, also, that the articles appearing in *Philosophical Transactions* carried a different emphasis. Whereas previously the papers had usually been designated "accounts"—the unmistakable mark of the historical paper—those now appearing stressed "causes, conjectures, hypotheses, thoughts." This was a far cry from Robert Hooke's seventeenth-century ultimatum to the Society's members:

> . . .till there is a sufficient collection made of experiments, histories, and observations, there are no debates to be held at the weekly meetings of the Society concerning any hypothesis or principal [sic] of philosophy, nor any discourses for explicating any phenomena, except by special appointment of the Society or allowance of the President.

Now, however, the aim of the Society's research had become "the knowledge of causes and the secret motions of things," and the focus of attention was upon principles and the application of principles rather than upon fact per se.

A review of the articles in *Philosophical Transactions* suggests that during this period three types of scientific investigation were particularly favored. (From one of these, however, American Fellows were debarred because the material lodged in the London archives was not available to them.) One of the English Fellows, in a paper entitled "Conjectures concerning the cause, and observations upon the phenomena of earthquakes" (1760), had examined the Society's data on earthquakes and had made good use of the histories sent in by Winthrop and Dudley.

The Society also publicized the discoveries resulting from the correct application of such recently expounded principles as those of Newton and Linnaeus. Linnaeus was not made a foreign Fellow of the Society until 1753, but by that election the Society acknowledged the contribution he had already made to science. In 1744 Peter Collinson had reported to Linnaeus:

> Your system, I can tell you, obtains much in America. Mr. Clayton and Dr. Colden at Albany on Hudson's river in New York, are complete professors; as is Dr. Mitchell at Urbana on Rapahanock river in Virginia. It is he that has made many and great discoveries in the vegetable world.

The popular judgment concerning the writings of Linnaeus was probably echoed by Alexander Garden when he wrote:

> These have first introduced into Botany the science of demonstration, founded upon mathematical principles; and at the same time a sound, as well as easy mode of classification.

In the mid-fifties, Garden, by this time one of the American disciples of Linnaeus, was himself making "many and great discoveries." The English Fellow John Ellis was most anxious to have Garden's descriptions of his new genera published in the *Transactions*, but Garden offered the Society only a few of his Carolina plants. Most of his material was sent to Linnaeus. John Mitchell also carried on a correspondence with Linnaeus between 1745 and 1750; in the course of this exchange of letters Mitchell obtained the data on the manufacture of potash that he presented to the Society in 1748.

It was natural, if only because Newton was President of the Society during the first quarter of the century, that the

early eighteenth-century American Fellows should follow his career with interest. Champions of Newton showed concern for their favorite in the battle of words then raging. Paul Dudley asked the advice of the Society's Secretary concerning "a new treatise of philosophy in opposition to Sir Isaac Newton," which he had seen advertised. "I should be glad," he said, "to have your opinion of the book and whether it be worthy sending for."

The principal interest of the later American colonial Fellows, however, centered on the principles Newton had set down in the *Principia* and the *Optics*. By 1752 an American correspondent could remind Franklin, "On this occasion I think it proper to observe to you that in the [*Optics*], what Sir Isaac has proved is generally taken for granted and supposed to be known." Even passing comments concerning Newton refer to the Newtonian theories rather than to the man. Garden found it "surprising to see how exactly the various phaenomena of the indigo beating, quadrate with and confirm Sir Isaac's theory of the composition of colorific particles of bodies."

The American Fellows who appear to have studied and applied Newtonian principles most effectively were Dr. Mitchell and Professor Winthrop. In 1744 Mitchell's paper, entitled "On the causes of the different colours of people in different climates," was read at two meetings of the Society; it is reported that the Society's members were much impressed by this "very curious dissertation concerning the Colour of the skin in Negroes." Mitchell's reliance on Newtonian principles is indicated by his reference to the *Optics* thirteen times in a paper of forty-eight pages.

Frederick Brasch is of the opinion that Professor Winthrop was "Newton's first critical disciple in the American colonies." Certainly *Thoughts on Comets* reflects Newtonian influence at every point. Winthrop had derived the solutions to the five problems which were posed from the principles set forth in the *Principia*. There is reason to believe Winthrop intended his paper to be a supplement to Newton's work. The form of his paper closely followed that of the *Principia*, and the only footnote references were to that work. In 1774 the *Transactions* printed Winthrop's "Remarks upon a passage in Castillione's Life of Sir Isaac Newton," in which Winthrop protested against the biographer's misinterpretation of Pemberton's text and expressed fear that Newton would thereby be put in an inferior light "in the eyes of foreigners."

A third type of scientific investigation given publication in the *Transactions* was one indicating the value of the experimental method advocated and outlined in Newton's two famous works. Newton's emphasis on "experiments and observations" made that term a commonplace. It is highly improbable that Benjamin Franklin chose only by accident the title *Experiments and Observations* for the volume on which his fame as a scientist largely rests. Franklin's friend Dr. Arthur Lee, in the year of his election into the Society, submitted a series of twenty-five experiments on the Peruvian Bark. The opening words of his paper reveal how thoroughly conversant he was with the patter in vogue during this particular period. "The object of experiments," he announced, "is to establish principles, on which practice may be conducted in the most expeditious and unerring manner."

Just as the Society sponsored and directed the project of history collection in the earlier days, so between the forties and the seventies the Society no less vigorously encouraged cooperative work on two problems considered at that time to be of major importance. These were the determination of the nature and properties of electricity and the "grand problem of the parallax," as Professor Winthrop phrased it. The

transits of Venus over the sun in 1761 and 1769 offered two golden opportunities for solving the latter problem.

Obviously, the exact determination of the sun's distance from the earth was not possible unless many astronomers submitted their observations for comparative study. Therefore, from *Philosophical Transactions* came Professor Hornsby's pleas for cooperation, and the London Fellow who was the Astronomer Royal issued a pamphlet of detailed instructions. The Professor of Astronomy at Harvard College did not need reminders from London of the importance of the two events, but the trouble Winthrop took in order that his account of the 1761 transit should reach London indicated how anxious he was to contribute his share in the cooperative work the Society was directing. He sent in his original report to an English Fellow; a popular account of the transit he published in Boston. The absence of Winthrop's observations from Volume LII of the *Transactions*, which was devoted almost exclusively to reports submitted by observers, probably prompted Winthrop to send a second letter. When in 1764 he learned that an English Fellow had access only to the Boston account, Winthrop once again repeated his description and made certain of ease of mind by requesting publication of his letter in the *Transactions*. His observation of the transit of 1769 reached London without mishap.

On January 2, 1769, the American Philosophical Society united, on terms of equality, with the American Society held at Philadelphia for Promoting Useful Knowledge. The first major cooperative project after this merger of the two rival scientific societies was the 1769 transit of Venus. Perhaps Benjamin Franklin, the newly elected president of the society at Philadelphia, encouraged cooperation with the Royal Society; certainly he saw to it in 1768 that the instructions of the Astronomer Royal reached Professor Winthrop's hands.

The Society's program for research on electricity was probably spearheaded by William Watson who, in 1745 and 1746, read a series of papers before the Society. In his discourse entitled "Experiments and observations tending to illustrate the nature and properties of electricity," Watson reviewed all the important electrical experiments that had been made; he recommended that in the future cooperators in research on electricity adopt Newton's experimental method outlined in the *Optics;* and he closed his long account by listing ten queries on electricity designed to provoke and guide future investigation. The Society had long used this device of publishing desiderata on a subject as a means of recruiting more workers. By March 1747 Franklin was thanking Peter Collinson for "your kind present of an electric tube, with directions for using it." And that marked, of course, the beginning of his remarkable electrical experiment and discovery.

Franklin immediately identified himself with the work being done by the Society's experimenters. Indeed, I. Bernard Cohen, editor of *Benjamin Franklin's "Experiments and Observations"* (1941), believes that the influence on Franklin of the articles appearing in the *Transactions* and of such works as Watson's was so strong as to be detrimental. Certainly the *Transactions'* influence upon Franklin was as sudden as it was strong. In his paper of 1737, entitled "Causes of Earthquakes," which appeared in the *Pennsylvania Gazette,* Franklin cited the *Transactions* of no later date than the seventeenth century. Had he been familiar with Dudley's account of earthquakes that appeared in the 1735 *Transactions*, he undoubtedly would have included it in his compilation. Because from the outset of his experiments Franklin was intent on discovering something "new,"

it was necessary that he acquaint himself with the electrical research already done. It is, therefore, not surprising that four months after his thank-you note to Collinson Franklin showed himself thoroughly conversant with the current *Transactions*.

By 1752, when Franklin's own papers began appearing in the *Transactions*, his role in the Royal Society was largely one of judge and counselor. He added his explanation to that of Gowin Knight concerning the electrical phenomena described by Captain Waddell; he supplemented the experiments of John Canton and correlated the work of Canton and of Delaval. Franklin's "letter concerning an electrical kite" contained an account of a decisive experiment through which he verified his own hypothesis.

Such was the Society's respect for Franklin's opinions that it solicited his "remarks on Beccaria's experiments in electricity." When inquiry was current regarding the possible use of electricity in paralytic cases, the Society asked for a report from Franklin. In 1773 he was asked to serve on one of the Society's committees, and his report explained why his pointed (rather than Wilson's blunted) lightning rods were being recommended for use on the powder magazines at Purfleet. The prestige Franklin enjoyed is suggested by the action of the Royal Society in awarding him the Copley Medal even before he was elected a member.

Although the study of electricity resulted in no discoveries by other American Fellows, the subject was of absorbing interest to them. It required an exchange of five letters for Professor Winthrop fully to confide his thoughts on electricity to Franklin. Alexander Garden's behavior was typical. Like Franklin, he was sent a piece of electrical apparatus by an English Fellow; like the other zealous virtuosi, he showed familiarity with the literature of electricity; and, like all scientists of this period, he did not hesitate to indulge in suppositions.

These American Fellows of the late colonial period showed a strikingly different attitude toward their own work and their status as scientists from that of such a man as Paul Dudley, whose collection of historical data had been made earlier in the eighteenth century. Dudley wrote to the Society's Secretary in 1723:

> I am very glad what I sent. . .came safe to the Society, not that anything of mine is really worth their acceptance, but that they will be convinced at least how willing I am to make some return for their great respect to me, besides the incouragement it will give me to repeat my duty by the next conveyance. . . .Sir your very affectionate humble servant.

Although the phrasing of the close of his letter was conventional, it described Dudley's spirit precisely.

Quite different is the correspondence of Garden regarding the specimens he sent to Upsala. Garden seemed to relish his debates with the great Linnaeus. On one occasion, when Linnaeus had been the loser, Garden reported to John Ellis: "I came off conqueror in our dispute about the new genus *Anamelis*, on which I plume myself not a little, but his candour charms me."

John Mitchell believed his observations on the "Colour of the skin in Negroes" good enough to be offered in competition for a prize, but because his paper did not arrive at Bordeaux by the required date, it could not be judged. All these circumstances were explained by Peter Collinson when he presented Mitchell's paper to the Royal Society in 1744.

By 1754 Franklin could feel he was no longer under any obligation to answer his opponents personally. ". . . will not one's vanity," he wrote James Bowdoin, "be more gratified in seeing one's adversary confuted by a disciple, than even by one's self?"

Professor Winthrop's experience of 1769 should have been an object lesson in self-confidence. During his observation of the second transit of Venus he made a discovery that he knew would challenge a theory held by two distinguished English Fellows. Winthrop's incertitude was apparent when he wrote to Franklin in London, "I will make no doubt you will immediately discover where the error lies and shall take it as a great favour if you will point it out to me." Back came the report on the test the Society had commissioned Richard Price to make: "Your ingenious friend," he announced to Franklin, "is right."

One factor inducing this change of attitude in the American Fellows is that, whereas the early work done for the Society required of the men only zeal and accuracy, work of the later period brought into play not merely the simplest but the highest mental powers. The very form of the papers would provoke different attitudes: one was factual exposition; the other, argument by proof.

Another reason why these men respected their own work is perhaps too obvious for comment. The particular emphasis the Society was giving scientific investigation during this period stimulated the active cooperation of men schooled in scientific learning and techniques. Most of the late colonial Fellows—Winthrop, Mitchell, Garden, Lee (Franklin being the glaring exception)—were professional scientists. Since cooperation had become a matter of course to these men, they no longer needed instruction from the Society as to its virtues. Franklin and Winthrop showed their mastery of the cooperative technique by initiating their own projects of cooperative work. One example was Winthrop's organization of the expedition to Newfoundland in order to observe the transit of Venus in 1761. From an account in *Sky and Telescope* (1943) we learn that numerous American observers in 1769 looked to Winthrop as their director.

Franklin's behavior in 1753 showed how welcome was any opportunity to supervise a cooperative venture. In that year a French correspondent of the Academy of Sciences had dispatched from Paris a letter to the astronomers at Quebec, asking them to contribute observations of the transit of Mercury. The letter, which came to New York en route to Canada, was unsealed, and perhaps for that reason the reading of it provoked no pangs of conscience. At once the instructions to the astronomers were copied, translated, and sent to Philadelphia. Franklin struck off fifty copies and gave them wide distribution. The report from Franklin's cooperator at Antigua was printed in the *Transactions*, in it the correspondent gently chided Franklin for sending half a dozen circulars when one was sufficient for the few men at Antigua interested in astronomy.

Alexander Garden did not direct a cooperative project, but he showed himself capable of outlining strategy for a proposed cooperative gardening experiment in Charleston and other colonial centers.

To the earlier colonial Fellows London had seemed the center of their scientific world; it was not so to the Americans of the later period. Garden, for example, worked with a will for English Fellows, but his major activity was the collection of American flora and fauna for Linnaeus. Garden had already been honored by membership in the scientific societies at Edinburgh and Upsala when in 1773 he was made a member of the Royal Society.

Perhaps the earlier Fellows had tended to move wholly within the orbit of the Society because they were elected to membership soon after they had begun their scientific activity. Unlike these men, Professor Winthrop began contributing papers to the Society in 1740; yet twenty-five years later Ezra Stiles reminded Franklin,

"I hope you will not forget to recommend that ingenious and learned gentleman, Professor Winthrop, to the honors of the Royal Society, now that you are in London." Franklin's contributions flowed to London in a steady stream for nine years before the Society voted him a Fellow.

What had caused this delay in the election of Winthrop or, indeed, of Franklin was not, I think, lack of appreciation of either their genius or their service to the Society. The policies and procedures of the Society were not static, but they did not keep pace with the growth of science. Early in the century the Society had been able to use the bait of election into the Society as a means of increasing scientific work. As the century advanced, however, productive scientists became so numerous that the Society was no longer prompt in awarding membership to its own cooperators, and policy regarding membership became increasingly cautious.

There is little evidence that the Society's neglect or its restrictive measures concerning new members aroused resentment in the Americans. Apparently, their scientific progress rather than their *amour-propre* was the first concern of these men. A serious obstacle to that progress, Alexander Garden believed, was not removed merely by election into the Society. When he was informed of the fee required of the newly elected member, he wrote:

> I think it would be very needless in me to advance 25 guineas for the name, as I should never have any access to that instructive conversation, which you who reside in London must mutually enjoy at your meetings. . . .Hence, though the sum be inconsiderable, yet I judge it would be mis-spent.

Garden thus clearly implied that the scientist's major need was the stimulation and assistance offered by the exchange of ideas, of experience, and of material between scientists at work on the same problems. But, if colonial Americans were to profit by exchange of scientific opinions, they had to carry on as large a correspondence as possible with scientists both overseas and at home.

Of this Benjamin Franklin was fully aware. His 1743 proposal for an American colonial scientific society was modeled on the Royal Society, but the difference between the two plans is significant. The committees of the Society usually initiated and directed scientific investigation; Franklin's were intended to function largely as committees on correspondence. The chairmen were to direct letters of inquiry and comment coming into Philadelphia to the scientists who shared the interests of the correspondents.

Certainly the colonials would not be content to rely wholly on their correspondence from across the seas, however. The long delay in receiving a reply and the frequency with which letters and specimens failed to reach their destination would increase the desire of Americans to find more satisfactory means of filling this need of close and constant contact with fellow-scientists. The value of "instructive conversation" had been proved by Garden when his visit at New York with Cadwallader Colden in 1754 inspired him to begin his correspondence with Linnaeus and to undertake a botanical study of the Charleston district. Franklin was fortunate to find in Philadelphia three such fellow-experimenters in electricity as Kinnersley and Syng and Hopkinson. Was it not almost inevitable, therefore, that the American scientists should seek some means of meeting regularly and forming a permanent organization? Hence, the two American colonial Assemblies in 1780 did only what was to be expected when they granted charters to the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge and the American Academy of Arts and Sciences at Boston. It was, however, most unlikely that American scientists would completely ignore the

work issuing from London merely because for reasons of efficiency the small independent societies had been created.

Of necessity, the Royal Society's attitude toward American scientists underwent a change at the time of the Revolution. Those Americans who had previously been termed Home Fellows became Foreign Fellows; in the future the Society was to consider eligible for election only those Americans whose reputation as distinguished scientists had already become world-wide. Thus, the Royal Society stood ready to honor America's men of scientific genius, but it no longer essayed the discovery of scientific talent and the development of the scientific temper among Americans. It therefore became the responsibility of the societies in this country to encourage and advise American scientists, amateur or professional, and to educate the American public in scientific objectives and techniques.

Because the societies at Philadelphia and Boston were so patently modeled on the Royal Society, Americans must have believed that the English organizational plan was in general a good one. Is it not probable, however, that these American societies were less duplicates than adaptations of the London plan? New times and conditions usually require some changes in traditional method. Why these methods were altered and what were the consequences of such modifications are questions which, if answered, might well explain to some degree the tempo of scientific growth in America in the years following the Revolution.

The Philadelphia Society for Promoting Agriculture, for example, corresponds in function to the georgical committee of the Royal Society. Did the creation of an independent organization result in more efficient work? Did it provoke greater public interest, an increased number of cooperators? Were Fellows of the American Philosophical Society also members of the group promoting agriculture, or did they function in an advisory capacity?

Philosophical Transactions was issued a number of times each year, but the journals of the American societies appeared so infrequently that the scientists themselves—much less the general public—could not promptly learn of the latest scientific discoveries. Only by publications supplementary to the *Transactions* of the American societies could the literature of science flow in a steady stream to the scientist, the mechanic, the farmer. To what degree was the American society aware of this need? What steps were taken to fill it?

Students of American intellectual history would be particularly interested to learn if adaptations of the English practices resulted in a more widespread and effective education of the common man in the aims and methods of science. Since Americans came firmly to believe that the pursuit of happiness was somehow linked with the progress of science, and that if men worked together in the true spirit of cooperation they could hope for success in the human adventure, it is desirable to know what role the American scientific society may have played in the formation of such popular concepts as these.

In colonial times the Royal Society had furnished Americans the encouragement and supervision they sorely needed. The Society's plan of organization and membership and its promotional tactics had made it possible for a direct influence to be exerted upon the men of this country. My notes upon the work and attitude of fourteen of the Society's American Fellows may have suggested how profound and how formative that influence was.

LOUIS AGASSIZ AND MEN OF LETTERS*

By JAMES D. TELLER

Dr. Teller (Ph.D., Ohio State) taught the history of science and of education at OSU from 1938 to 1943. During the war he was a research psychologist with the Army's Personnel Research Section, which constructed and validated all mental tests used in the selection and placement of men in the Army. His present duties as Chief of Employee Evaluation for The Adjutant General's Office, War Department, are a natural evolution. Dr. Teller's article celebrates the centennial of Louis Agassiz' arrival in the United States.

THE influence of Louis Agassiz on men of science is well known. His influence is attested not only by men of science, however, but also by men of letters. Although Henry David Thoreau was one of Agassiz' first collectors in America, he had no love for classification or dissection. He would send Agassiz a fish from the Concord River without wishing to know where Agassiz placed it in the scheme of the universe or what he found when he dissected it. Nevertheless, Agassiz never failed to cultivate Thoreau's society when he could. Thus, in declining Thoreau's request in 1849 that he lecture in Bangor, Agassiz pleads:

> My only business is my intercourse with nature; and could I do without draughtsmen, lithographers, etc., I could live still more retired. This will satisfy you that whenever you come this way I shall be delighted to see you,—since I have heard something of your mode of living.

The author, however, tended to avoid the man of science, although he recognized in Agassiz the qualities that gave him so much distinction.

In contrast with his relations with the recluse of Walden Pond, Agassiz was from the first a much-loved guest of George Ticknor's house. In spite of their differences, they took great pleasure in each other's company. As a trustee of the Museum, Ticknor often counseled with Agassiz. In a letter to Lyell dated April 5, 1848, Ticknor writes:

> Agassiz continues to flourish, and enjoys the same sort of popular favor he has from the first. His bonhomie seems inexhaustible; and how much that does for a man under institutions and in a state of society like ours I need not tell.

Ticknor and Agassiz both belonged to the "Friday Club." This was a dinner club formed in 1859. It was limited to twelve members and met once a fortnight. In addition to Agassiz and Ticknor, its membership included W. Amory, Sidney Bartlett, B. R. Curtis, C. C. Felton, W. W. Greenough, G. S. Hillard, R. M. Mason, W. B. Rogers, C. W. Storey, and H. P. Sturgis.

The Friday Club, however, was neither the first nor the most brilliant of the clubs with which Agassiz was associated. Two or three years before it was founded, a literary association, which finally became known as the "Saturday Club," had crystallized out of certain informal social meetings of a group of friends at "Parkers," "the 'Will's Coffee House' of Boston." The Club seemed to have shaped itself around the dinner meetings of Ralph Waldo Emerson and two or three of his friends. Gradually the little company gathered others to itself, until a group unique in the intellectual eminence of its members had been assembled. Some of these were contributors to *The Atlantic Monthly*, but the Club was not connected with the magazine. Holmes believed that

* References to quotations have been omitted at the request of the Editor.

the vitality of the Club was due to "its utter poverty in statutes and by-laws; its entire absence of formality, and its blessed freedom from speech-making."

The early group brought together by the Club is enumerated by Holmes as follows:

> During its first decade the Saturday Club brought together, as members or as visitors, many distinguished persons. At one end of the table sat Longfellow, florid, quiet, benignant, soft-voiced, a most agreeable rather than a brilliant talker, but a man upon whom it was always pleasant to look,—whose silence was better than many another man's conversation. At the other end of the table sat Agassiz, robust, sanguine, animated, full of talk, boylike in his laughter. The stranger who should have asked who were the men ranged along the sides of the table would have heard in answer the names of Hawthorne, Motley, Dana, Lowell, Whipple, Peirce, the distinguished mathematician, Judge Hoar, eminent at the bar and in the cabinet, Dwight, the leading musical critic of Boston for a whole generation, Sumner, the academic champion of freedom, Andrew, "the great War Governor" of Massachusetts, Dr. Howe, the philanthropist, William Hunt, the painter, with others not unworthy of such company. And with these, generally near the Longfellow end of the table, sat Emerson, talking in low tones and carefully measured utterances to his neighbor, or listening, and recording on his mental phonograph any stray word worth remembering.

Of the fifteen persons listed by Holmes, ten are included in Emerson's list of twelve members for 1856. Hawthorne, Sumner, Andrew, Howe, and Hunt are not included. However, S. G. Ward and H. Woodman are listed. Holmes himself, along with C. C. Felton and J. E. Cabot, appears first in Emerson's list for 1857. The Club had also had among its members James T. Fields, William H. Prescott, Henry James, W. D. Howells, T. B. Aldrich, Charles Francis Adams, Francis Parkman, and many more scarcely less well known.

Holmes did not object when someone referred to the Club as "The Mutual Admiration Society," for he thought that "all generous companies of artists, authors, philanthropists, men of science, are, or ought to be, Societies of Mutual Admiration." Whipple, however, believed that admission to the Club "depended rather on antipathy than sympathy as regards the character and pursuits of its members." Agassiz prized the Club because of the opportunities it afforded him for meeting with persons who were not particularly interested in the subjects that absorbed his own intellect and taste.

Brief descriptions of three meetings of the Club at different times in its history will serve to illustrate Agassiz' intimate relations with its members. One of the early meetings of the Club was that in honor of his fiftieth birthday on May 23, 1857. In reporting it Emerson entered the following lines in his *Journal:*

> Agassiz brought what had just been sent him, the last coloured plates to conclude the First Volume of his Contributions, etc., which will now be published incontinently. The flower of the feast was the reading of three poems, written by our three poets, for the occasion. The first by Longfellow, who presided; the second by Holmes; the third by Lowell; all excellent in their way.

Longfellow wrote in his *Journal* that they "sat down at half-past three, and stayed till nine." It was at this meeting that Longfellow read in a "very modest, delicate musical way" the charming poem that begins as follows:

> It was fifty years ago
> In the pleasant month of May,
> In the beautiful Pays de Vaud,
> A child in its cradle lay.
>
> And Nature, the old nurse, took
> The child upon her knee,
> Saying: "Here is a story-book
> Thy Father has written for thee."

Whipple says that Agassiz shed tears as the last stanza referring to his mother was read.

On April 23, 1864, the Club met "to keep the birthnight of Shakespeare, at the end of

the third century." Seventeen members and fifteen guests were present. William Hunt sent a full-length picture of Hamlet. Emerson reports that "it was a quiet and happy evening filled with many good speeches, from Agassiz who presided (with Longfellow as *croupier*, but silent), . . . and a fine poem by Holmes. . . ."

Although it was almost impossible to induce Longfellow to speak in public, even when he was called upon at the dinner to the Grand Duke, Holmes tells us that "at the last Club he offered the health of Agassiz—who was just about to leave on an exploring expedition of the Pacific Coasts of South America,—and made a very neat little speech, which was received with much applause. . . ." Longfellow himself writes in his *Journal* for November 26, 1871:

> Drove over to the Navy Yard in the afternoon with my girls to see the little steamer (the "Hassler") in which Agassiz is going round the Cape. Yesterday at the Club dinner we drank his health at parting. I proposed it thus: "Gentlemen, I am reminded that we shall not again have with us for a year and a day our dear Agassiz, who sits there at the head of the table so joyous and unconcerned. I shall, therefore, for once break through our usual custom and propose his health. Wordsworth once said that he could have written the plays of Shakespeare if he had had a mind to. And I suppose that on an occasion like this I could make a speech,—if I had a mind to. But I shall do nothing of the kind; I shall limit myself to proposing "The health of Agassiz; his deepest sea-soundings shall not be deeper than our love and admiration for him."

Something of the intimacy of Agassiz' relations with his fellow-clubmembers can be obtained from James Russell Lowell's description of the Club as he presents it in his elegy on Agassiz.

The brilliance of the meetings of the Saturday Club can be better appreciated from a remark Lowell made in a letter written in 1883 to C. E. Norton telling about the cultural advantages of his dearly beloved London. He writes:

> In plain living and high thinking I fancy we have, or used to have, the advantage, and I have never seen society on the whole, so good as I used to meet at our Saturday Club.

Holmes, too, expresses a high appreciation of the Club in a letter to Motley dated February 16, 1861:

> The Club has flourished greatly, and proved to all of us a source of the greatest delight. I do not believe there ever were such agreeable periodical meetings in Boston as these we have had at Parker's.

Few of the members of the Club were as sentimentally attached to it as was Holmes. In later years, as death began to claim the early members of the Club, there came to be something pathetic about his attachment to that which still had existence but which was, for him, almost all a memory. In 1883, after Agassiz, Longfellow, and Emerson had died, he wrote to Lowell in England:

> I go to the Saturday Club quite regularly, but the company is more of ghosts than of flesh and blood for me. I carry a stranger there now and then, introduce him to the members who happen to be there, and then say: "There at that end used to sit Agassiz,—here at this end, Longfellow,—Emerson used to be there, and Lowell often next to him . . . .

Holmes had a great admiration for Agassiz and used to call him "'Liebig's Extract' of the wisdom of ages." Once, when Agassiz was away upon one of his scientific excursions among some remote, semicivilized peoples, Holmes remarked: "I cannot help thinking what a feast the cannibals would have, if they boiled down such an extract!" A gentleman once commented very unfavorably upon this jest, explaining, with more than British gravity, that it was a poor one because cannibals don't care for wisdom and would only have relished Agassiz because he was plump!

Of all Agassiz' associates in the Saturday Club, none was so close to him as Longfellow. These two friends were almost forty years old when they met, an entry in

Longfellow's *Journal* of January 9, 1847, noting the meeting thus:

> In the evening, a re-union at Felton's, to meet Mr. Agassiz, the Swiss geologist and naturalist. A pleasant, voluble man, with a bright, beaming face.

Less than a month later, references to Agassiz are made without the title, for the two had already become intimate. Visitors to Longfellow's "Craigie House" noticed the cordial relations between the two friends. Thus, Robert Ferguson, of Carlisle, England, in giving an account of his visit in 1864 writes:

> ....And often, too, comes Agassiz, with his gentle and genial spirit, his child-like devotion to science, and—or he would not be a true son of his adopted country—his eager interests in the politics of the day. We went to hear one of his lectures at the University,—not one of what are considered the popular lectures, but one of a special course to a small class. Yet it was deeply interesting .... Between the Poet and the Naturalist there exists a very warm friendship, and among other poetical tributes, Mr. Longfellow has achieved the feat—for so it must seem to us, with our rigid English tongues—of addressing to his friend, in the October number of the *Atlantic Monthly*, a gay and graceful chanson in his native language.

Longfellow also included a sonnet to Agassiz in the group entitled "Three Friends of Mine."

In spite of the fact that Emerson's mind was far from being of the scientific pattern, he and Agassiz were the most genial of friends. Emerson's prejudice against science is shown in his poem "Blight," in which he complains that the "young scholars who invade our hills"—

> Love not the flower they pluck, and know it not,
> And all their botany is Latin names. . . .

Further, it is not improbable that Emerson's genial companionship with Agassiz, with his conception of Nature as "thoughts of the Creator" and his delightful social qualities, gave him a kinder feeling toward men of science and their pursuits than he had entertained before he met Agassiz. That Emerson appreciated Agassiz is attested by several entries in his *Journals*, three of which we shall quote. In 1864 on the occasion of a visit from Stanley, Phillips, Channing, Alcott, and Agassiz, he writes:

> Agassiz is really a man of great ability, breadth, and resources, a rare and rich nature, and always maintains himself,—in all companies, and on all occasions. I carried him to Mrs. Mann's, and afterwards, to Bull's, and, in each house he gave the fittest counsel in the best way. At the Town Hall, he made an excellent speech to the farmers, extemporaneous, of course, but with method and mastery, on the question of the location of the Agricultural College, urging the claims of Cambridge.

In 1866, he visited Agassiz at Nahant and reported:

> He is a man to be thankful for, always cordial, full of facts, with unsleeping observations, and perfectly communicative.

In 1869, in describing Agassiz' address at the Humboldt Centennial Celebration, he concludes with the following evaluation of Agassiz:

> He is quite as good a man as his hero, and not to be duplicated, I fear. I admire his manliness, his equality always to the occasion, to any and every company,—never a fop, never can his manners be separated from himself.

In the summer of 1858 Emerson, Agassiz, Lowell, Wyman, William James, Stillman, and five others set up a "Philosophers' Camp" in the Adirondacks. Longfellow refused to go because he feared Emerson carrying a gun. Stillman has left a faithful painting of the first camp of the Adirondack Club, which now hangs in the Concord Public Library. Agassiz is one of a trio dissecting a fish. Stillman is instructing a quartette, including Lowell, in the use of the rifle. Emerson stands alone in thought. Emerson has enshrined this sojourn in the

wilderness in a poetic chronicle entitled "The Adirondacks."

Lowell confessed that he understood and liked Agassiz better as he himself grew older and perhaps less provincial. He was in Florence when Agassiz died and wrote a long poem in the nature of an elegy on Agassiz. In a letter to C. E Norton dated February 26, 1874, he related how he came to write the verses:

> His death came home to me in a singular way, growing into my consciousness from day to day as if it were a graft new-set, that by degrees became part of my own wood and drew a greater share of my sap than belonged to it, as grafts sometimes will. . . . It was curious to me after it was done to see how fleshly it was. This impression of Agassiz had wormed itself into my consciousness and without my knowing it had colored my whole poem. I could not help feeling how, if I had been writing of Emerson, for example, I should have been otherwise ideal. But there it is, and you can judge for yourself. I think there is some go in it somehow, but it is too near me yet to be judged fairly by me. It is old-fashioned, you see, but none the worse for that.

The last eleven lines of Lowell's long poetic tribute to his friend can well serve to summarize Agassiz' magnetic power over people:

> We have not lost him all; he is not gone
> To the dumb herd of them that wholly die;
> The beauty of his better self lives on
> In minds he touched with fire, in many an eye
> He trained to Truth's exact severity;
> He was a Teacher; why be grieved for him
> Whose living word still stimulates the air?
> In endless file shall loving scholars come
> The glow of his transmitted touch to share,
> And trace his features with an eye less dim
> Than ours whose sense familiar wont makes numb.

ADVANCE REGISTRATION

114th Meeting of the A.A.A.S., Chicago, December 26–31, 1947

Those planning to attend the Chicago Meeting of the Association, December 26–31, may register now by sending the correct registration fee ($2.00 for members and college students, $3.00 for nonmembers) to the Washington office of the Association, 1515 Massachusetts Ave., N. W. The *General Program* will be mailed on December 1 to all who register before that date, in time to study its contents and decide at leisure which of the many hundreds of sessions and special functions they may most profitably attend. Moreover, they will be saved the time of registering during the meeting, and their names will be included in the special directory of registrants that will be available for inspection in all the headquarters hotels.

The *General Program* will list the papers of the sections and societies meeting with the Association, including the time and place of each session. It will also contain announcements regarding general sessions, the International Science Exhibition, eating facilities, transportation, mail and messenger service, and a directory of speakers and presiding officers. Readers will find the Summary of Sessions most useful.

Registration fees have been received since August 15, and they will be accepted for mail distribution of the *General Program* until December 10. Payments received after that date will be held and placed on file on December 26 at the main registration center located adjacent to the Exhibition in the Stevens Hotel. Upon identification, registrants will be given a copy of the *General Program*, and their registration cards will be placed in the Visible Directory. To avoid delay in receipt of your copy of the program during the Christmas mailing rush, please send your registration fee in time for it to reach the Washington office before December 1.

Book Reviews

MANKIND CREEPS SLOWLY ON

Science Advances. J. B. S. Haldane. 253 pp. $3.00. Macmillan. New York. 1947.

IN THIS collection of about seventy short, informative essays, Professor Haldane presents a rich variety of scientific topics, with illuminating comments on the social significance of science and of scientists. Some of the essays have been reprinted from periodicals not likely to be on the general reader's list, and are doubly welcome on that account. The eight sections of the book treat Some Great Men (ten scientists); Animals and Plants; Human Physiology and Evolution (two sections); Medicine; Hygiene; Inventions; Soviet Science and Nazi Science; Human Life and Death at High Pressures—all with the firm touch of the man who knows whereof he writes.

The preface is a candid apology in reverse for fitting the facts described into a general framework of Marxism. The fitting is done so unobtrusively that no sclerotic member of any Committee on Un-American Activities, reading the essays, need anticipate death from high pressure. Dialectical materialism is described as a "method of thought and action," and its prophets are quoted. Some, of course, will deplore this temperance, preferring Bertrand Russell's sacrilegious lexicon of Communism, which equates Yahweh to Dialectical Materialism and Hell to the Punishment of the Capitalists.

As may be inferred from the titles of the sections, the book is mostly about the life sciences and their human importance. There have been several excellent accounts of the physical sciences for the general (and professional) reader; these essays are a complement for the life sciences. The common cold, causes of cancer, the drink trade, cosmetics, X-rays and their dangers, and many other topics of importance to professionals and laymen alike are plainly and interestingly presented. Dozens of books have been written on the conflict of science and theology. The following statement of fact (p. 131) says more than the lot of them: "A wedding-ring does not prevent venereal infection."

E. T. BELL

California Institute of Technology

THINGS TO COME

The Future of Television. (Rev. ed.) Orrin E. Dunlap, Jr. xi + 194 pp. $3.00. Harper. New York. 1947.

MR. DUNLAP'S book is not a technical book on the subject of television but deals chiefly with its economic, social, and artistic aspects. These topics are not treated in a sufficiently coherent manner, however, and many good thoughts are put together in a mosaic fashion.

The mutual effects of television and such media as the theatre, the films, and sound broadcasting upon each other are plausibly treated, though necessarily in a speculative vein. A very brief history of television is given, together with a condensed explanation as to how it works. Unfortunately, almost the entire book deals with the state of the art up to the outbreak of World War II. Only the last few pages mention what has happened during the past two important years.

Possibly owing to the author's affiliation

with RCA, the reader is presented with an overwhelming array of RCA achievements, to the partial exclusion of contributions from other sources. As an example, nothing is mentioned of the pioneering in the field of color television by the Columbia Broadcasting System. Instead, the author attaches too much significance to the statements of those in the industry who play down the importance of color in the movies and in television.

The Future of Television can, at best, give the reader only a sketchy acquaintance with the types of problems that confront television today.

Peter C. Goldmark

Engineering Research and Development Department
Columbia Broadcasting System Inc.

FOR STARGAZERS

Making Your Own Telescope. Allyn J. Thompson. xi + 211 pp. Illus. $3.50. Sky Pub. Cambridge, Mass. 1947.

FIFTY years ago, the great popularizer of astronomy, Garrett P. Serviss, wrote that if the pure and elevated pleasure to be derived from the possession of a good telescope were generally known, no instrument of science would be more commonly found in the homes of intelligent people. Today, thanks to the telescope-making movement, the means of exploring the wonderlands of the astronomer are within the reach of everyone, and hundreds of people of all ages are scanning the heavens with instruments of their own making.

Mr. Thompson has guided many novices in the exacting but fascinating work of grinding and figuring mirrors for reflecting telescopes. His volume explains all the steps, from the assembly of the materials needed for the mirror to the adjustment of the finished telescope. This is done so clearly and reasonably, and with such carefully prepared diagrams, that a lone amateur with no previous knowledge of optics could produce an effective instrument. In fact, the new observatory director, after a pleasant period of becoming familiar with the more glamorous celestial wonders, may even use his telescope to add to scientific knowledge by systematic observations of variable stars, sunspots, and occultations of stars by the moon.

The opening chapter gives the history of the development of the telescope. This will inspire the tyro by giving him an appreciation of the significance of his undertaking. The major portion of the book is, of course, devoted to the attainment of the elusive parabolic surface of the main mirror, where the difference between perfection and mediocrity is a matter of but a few millionths of an inch. Successive chapters deal with the diagonal, tube, mounting, eyepieces, and practical observing information. A chapter entitled A Second Telescope is wisely included. This reviewer has helped dozens of telescope makers, using Mr. Thompson's original articles as reprinted from *Sky and Telescope* as reference. In nearly every case, the student begins to plan his second telescope before the first is even completed. The thrill of the first observations with a new telescope is actually a major experience in the life of its maker.

William A. Calder

Agnes Scott College

SOME REMARKS ABOUT AGRICULTURE

Jesse Buel: Agricultural Reformer. Harry J. Carman, Ed. xxxvi + 609 pp. $6.75. Columbia. New York. 1947.

THIS volume, the twelfth in the series of studies published by Columbia University on the history of American agriculture, is devoted to the lifework of Jesse Buel, a self-educated pioneer, born in Coventry, Conn., in 1778. With the benefit of only six months' schooling Buel began

his career in a Vermont printing office at the age of twelve. Within a few years he became a journeyman printer in New York City, later embarking on an extensive newspaper career in Lansingburg, Kingston, Poughkeepsie, and finally Albany, where he established the *Argus*, his fifth and most successful newspaper. His untiring industry and shrewd business acumen soon brought him funds sufficient to warrant the devotion of the rest of his life to reform of farming methods by well-planned experiments.

To that end he purchased eighty-five acres of poor soil in the "Sandy Barrens" just west of Albany, where he at once put into practice methods of tillage and seed selection and systems of crop rotation whereby he increased the yield manyfold in all crops, particularly in corn and potatoes.

Buel's remarkable success promptly attracted the attention of his farm neighbors, and his fame spread, not only in the United States, but to various European countries. The practices on his own farm, as well as the changes in farm methods that he recommended far and wide for the improvement of American agriculture, were based on his own experiments and the published scientific results of tests made in England, Scotland, Holland, and Germany.

So sure was he of his own discoveries and so impressed with the need of sound adult education for farmers that he gave generously of his time to lecturing, organization of agricultural societies, and to writing short, timely articles for the farm journals. A more pretentious undertaking was the preparation of a volume entitled *The Farmer's Companion*, dealing with the multitudinous problems the farmer has to meet.

Perhaps the most striking impression derived from reading the voluminous writings of this journalist, editor, farmer, lecturer, and philosopher of a century ago is the high percentage of his specific recommendations that might be applied with advantage to the average farm today. Indeed, his system of management of pastures and meadows is fully abreast of the best modern practices. Buel was a prophet as well as a pioneer.

E. V. Wilcox

Washington, D. C.

POPULAR SCIENCE

Physical Science in Art and Industry. E. G. Richardson. xi + 299 pp. Illus. 15/–. English Universities Press. London. 1947.

IN THIS book Dr. Richardson continues his lively discussions of the practical contributions of physics, with examples somewhat more advanced than those presented in his earlier *Physical Science in Modern Life*. The result is a book of scientific popularization whose maturity and versatility commend it equally to the general reader and to the physicist. Each will find stimulating extensions of his special interests—often with unexpected parallels—in the physics of locomotion, communication, pottery, culinary art, farming, hydrology, mining, fine arts, building construction, music, and textiles.

The author writes in an agreeable conversational style about subjects that have interested him, to many of which he has made original contributions. Mathematics is not used, but graphs of characteristics and performance are frequently presented.

One might wish that the line drawings had been done in uniform style and that more recent illustrations directly applicable to the text had been included. The general appearance of the book is pleasing, however.

The exposition is authoritative. Principles probably unfamiliar to the general reader are presented clearly and simply without misleading analogies.

The author takes a long-range viewpoint, often leading to interesting brief historical digressions. But there is little that savors of a philosophy of science or

concern about the social responsibilities of scientists. The wartime advances of physics are relegated to a single eleven-page chapter. Nuclear energy is not mentioned.

Occasionally, practices of long standing are alluded to as recent developments. Speaking of tube railways, the remark is made that sections 180 feet long and welded in one piece are now being tried. The equable temperature maintained underground makes it unnecessary to allow for expansion to the extent that is necessary in surface railways. One would not suspect from Richardson's account that sections of welded rail a mile or more in length have been used on U. S. railroads for decades, with rails subject to harmless stresses without displacement during the usual changes of temperature.

This book contributes pleasantly to the enlargement of the reader's interest in a wide range of phenomena whose understanding and control are aided by the methods of physics, often rather simply applied.

ROBERT L. WEBER
Department of Physics
The Pennsylvania State College

THE NAVAHO

Children of the People. Dorothea Leighton and Clyde Kluckhohn. xi + 277 pp. Illus. $4.50. Harvard. Cambridge, Mass. 1947.

IN SEPTEMBER 1941 an Indian Education Research Project was undertaken jointly by the United States Office of Indian Affairs and the Committee on Human Development of The University of Chicago. The aim of the program was to examine five tribes anthropologically, psychologically, and medically, in the hope that the data thus accumulated would help to increase the effectiveness of Indian administration in the future. The task of studying the Navaho, largest and most rapidly increasing tribe in the United States, was entrusted to two outstanding specialists; their findings are embodied in *Children of the People.*

Since both investigators had done much previous field work among the Indians in question, they wisely decided to publish their material in two complementary volumes. An earlier book, entitled *The Navaho* [SM, May 1947, 442], presents a broad picture of the tribe's environment and customs and provides a background for the present study of Navaho upbringing and personality development.

The first four chapters constitute Part I and were prepared by Professor Kluckhohn. They give an authoritative and interesting account of the major phases through which a Navaho individual passes on the journey from birth to death. Much emphasis is placed by the author on child training and its effect on the formation of personality traits. Somewhat unexpectedly, it was found that adult tribesmen show quite a bit of tension and worry in spite of the fact that as infants they had received a maximum of protection and gratification.

Dr. Leighton, who is responsible for the remainder of the book, deals with the data that were secured expressly for the Indian Education Research Project. On the basis of medical and psychological tests administered to 211 children drawn from three communities, it became apparent that all the Navaho tend to exhibit fairly similar personality patterns. Taken as a group they appear to be a practical folk, alert to the values of individuality, and endowed with energy, vitality, imagination, and high artistic capacities. Outwardly poised, and not prone to feelings of guilt over undiscovered misdeeds, they are nevertheless sensitive to criticism and ridicule. Although they are moody on occasion, they have a keen sense of humor and generally get much enjoyment out of life.

Both parts of *Children of the People* are so well written and illustrated that they

deserve to be widely read. Professional anthropologists and psychologists may disagree with some of the theoretical positions taken by the authors, but it will be universally agreed that Leighton and Kluckhohn have made available much fresh and valuable information about one of the most colorful tribes in North America.

MISCHA TITIEV

Department of Anthropology
University of Michigan

OF SHOES—AND SHIPS—AND SEALING WAX

The Origin of Things. Julius E. Lips. 496 pp. Illus. $5.00. A. A. Wyn. New York. 1947.

LEST we become overweening in our pride in the achievements of our age, Dr. Lips gives us impressive anthropological proof of the inventiveness of primitive peoples in all parts of the world. Nearly everything we value now seems to have been known in some form in earlier times. For instance, "the animal trap invented by primitive man has opened so many roads to modern technological development that no one who has followed the development of this first robot will deny its overwhelming importance."

Fact leaps upon fact in this well-ordered volume, and is enlivened by occasional philosophical comment on the culture under discussion. Whether it be cosmetics and body adornment, hunting, agriculture, architecture, history of the drama, medicine, or religion, it is told in vividly detailed style. Dr. Lips writes entertainingly but keeps his science ever in sight. To add additional clarity there are some fairly good photographs and more than 300 often small, but definitely superb, drawings by Mrs. Lips.

The book is enriched too by brief anecdotes of the manners and customs of aborigines: Among the Buryats of Asia "blacksmiths are the cream of society," whereas in Tibet they are "members of the lowest caste." No party among the Indians of Paraguay would be complete without the "tea wrongly known as mate." Since "paleolithic times Asia and Europe knew [ice] skates manufactured from bones." Occasionally "inflation threatens a primitive tribe—just as in our civilization." In the "African Pangwe country lightning is a 'black ball' which leaves its 'excrements' on the trees it hits in the form of resin, which is worshiped as holy."

In the next to the last chapter of the book are primitive fables in explanation of natural phenomena; they round out and enhance the preceding discussions. Finally, there is an extensive bibliography and an index.

MARJORIE B. SNYDER

Washington, D. C.

AL THIS NEWE SCIENCE THAT MEN LERE

The Strange Story of the Quantum. Banesh Hoffmann. xi + 239 pp. $3.00. Harper. New York. 1947.

THIS is an ambitious book. Without being technical, without using mathematics—which is the tool of reasoning and of explanation—the author tries to convey to the reader the fascinating story of quantum theories, including such difficult concepts as phase velocity, the algebra of matrices, Pauli's exclusion principle, the operational calculus, and many others. Comparison, analogies, whimsey—all these devices of popularization are used. The narrative is often interrupted by interesting historical remarks woven into the story. Another device, which was developed by Jeans into an art of popularization, is used here, though fortunately in moderation. This device consists in jumping from physics into metaphysics, in creating metaphysical thrills, and in raising the emotions over the

"mysteries" of the universe. Thus, we read in Hoffmann's book (p. 189): "And towering majestically over all, inscrutable and inescapable, is the awful [why awful?] mystery of Existence itself, to confound the mind with an eternal enigma;" or, again, on page 231: "If the mind of a mere Bohr or Einstein astounds us with its power, how may we begin to extol the glory of God who created them?" Many readers will like such metaphysical and religious passages. Those who don't will find enough in the bulk of the book to enjoy it in spite of occasional too-fancy writing. Yet there is one question which, unfortunately, I am unable to answer. Will a reader who does not know anything about quantum theory gain an understanding of the ideas the author tries with considerable skill to explain? My answer to this question is: I hope so, but I am not sure.

LEOPOLD INFELD

Department of Mathematics
University of Toronto

THE ATOMIC STORY

Atomics for the Millions. Maxwell Leigh Eidinoff and Hyman Ruchlis. xiv + 281 pp. Illus. $3.50. McGraw-Hill. New York. 1947.

IMMEDIATELY after The Bomb, there was a rash of hastily prepared and thoroughly inadequate books on atomic energy, and one monumental report—the Smyth Report. The first group had little or no understanding or background; the Smyth Report required that the reader have considerable background to understand it.

Beginning early this year, a second crop of atomic-energy books has appeared, all intended for public consumption, and all on a far higher level of understanding than the rush books of late 1945.

Atomics for the Millions is a new addition to this latter group of well-planned, well-written books with real understanding of the subject. Dr. Eidinoff was directly attached to the Manhattan District at Columbia University, at the University of Chicago site, and with the Kellex Company, who built much of the actual equipment. He knows the processes involved and the atomic side of the problem. Hyman Ruchlis is an educator, a science instructor, and has done much work in improving science courses in high schools. The teamwork of these two men is accurate, straightforward presentation of the opening of the atomic age, told in language adapted to both high-school students and the general public.

Properly, the book starts by explaining how we discovered atoms exist, how we determined that energy was there to be tapped, and how the first man-made transmutations were brought about. The discussion of the Manhattan District occupies about a third of the book in English language, without resort to Technicalese, a language foreign to those not brought up in its native habitat—the laboratory.

The last sixth of the book is devoted to a discussion of probable peacetime applications of atomic energy, methods of application, difficulties to be encountered, and the extent of available reserves of atomic fuels.

The influence of the professional educator is clear in this book in two respects. The first is the marked success in straining out the unnecessary polysyllabic, special-meaning words so useful to the professional scientist, but so confusing to the non-professional. The second is a somewhat less desirable effect; the short-sentence formula style of the pedagogical textbook did creep in, making a rather humorless though clear and accurate presentation.

The plentiful semicartoon illustrations by Maurice Sendak are excellent and extremely helpful in understanding the happenings in nuclear physics.

JOHN W. CAMPBELL

Astounding Science-Fiction
New York City

PLANTS THROUGH THE AGES

Ancient Plants and the World They Lived In. Henry N. Andrews, Jr. ix + 279 pp. Illus. $4.50. Comstock Pub. Ithaca, N. Y. 1947.

FEW books of strictly scientific information are as interesting and readable as Dr. Andrews' concise volume on ancient plants. Actually, the book is more than the title implies, for its content is not confined to discussions of plant fossils, but is really a series of treatises on the evolution of various plant groups from their first known beginnings in past ages to their modern descendants. Included also are related topics, such as the constitution of coal, climates of past ages as indicated by fossils, genealogies in the plant kingdom, and a short review of the development of paleobotanical science.

Throughout the volume one runs across such philosophical musings as only a scientist might utter. For example:

> The club mosses whose ancestors we trace back at least 300 million years are still a vigorous element of our living flora. Who can say, after he has seen them spreading like a carpet over the floor of our eastern woodlands, that these plants are approaching extinction? To be sure, they are not the masters that their Carboniferous forebears were, but shall we judge plants simply by their size? It is well-known that our own ancestors of the so-called Dark Ages were but disagreeable reminders of their highest levels of achievement of previous centuries. But we rose from that awful period of stagnation, and it is not impossible that such cycles will be repeated in the future (p. 161).

No errors of consequence, such as occasionally creep into scientific volumes, have been noted except in connection with the photograph of Roaring Mountain in Yellowstone National Park (p. 7). The statement is made that this modern hillside has been devastated by volcanic activity, whereas the devastation has been by thermal activity. Actual volcanism has long since ceased in Yellowstone. The serious reader will regret that the excellent reproductions of fossils, the line drawings, and the photomicrographs carry no indications of their relative reduction or enlargement. Others, as well as myself, may wonder also why the author has chosen to discuss *Lepidodendron* as the only significant lycopod tree of the Carboniferous forests, ignoring completely such equally important ones as *Sigillaria* and the relatively abundant *Lepidophloios*, and possibly others.

RAYMOND E. JANSSEN
Department of Geology
Marshall College

MAN OF GENIUS

Sun, Stand Thou Still. Angus Armitage. 224 pp. Illus. $3.00. Schuman. New York. 1947.

NICHOLAS COPERNICUS, trained chiefly in law and medicine, spent his life in the midst of the practical administrative problems of a canon of the Catholic Church in Poland. How could such a man produce a treatise on astronomy, *De Revolutionibus Orbium Celestium*, which ranks as one of the most important scientific books of all time? For that matter, how could Ptolemy produce the *Almagest*, or Newton the *Principia*, or Darwin the *Origin of Species*? An explanation of genius probably cannot be written; if written, it would not be understood. A part—the perspiration part—of the method of genius, however, is clearly described in Mr. Armitage's book. *De Revolutionibus* was no quick brain storm whipped up in a couple of weeks; it was the result of decades of patient, intelligent application.

The book under review falls naturally into three parts. The first part recounts the efforts of the early astronomers to systematize the apparent motion of celestial bodies and then explains the status of the problem at the time of Copernicus. The second part, which comprises the central half of the rather small volume, tells the

life story of Copernicus; it sets forth the particulars that have come down to us concerning the writing and printing of *De Revolutionibus* and gives a general account of the basic ideas in this historic document. The last part traces the principal stages in the establishment of the heliocentric system in the minds of men.

A typical paragraph, the first one in Part 3, follows:

> In these concluding chapters, we shall try to round off the story of Copernicus by giving some account of how his main ideas have come to be accepted as true. It is, of course, impossible to say how long this process took to accomplish. There were some people who accepted the Copernican theory right away. On the other hand, there may still be some cranks who maintain that the earth is fixed in space and that the heavenly bodies revolve round it. But we shall not be far wrong if we assume that the last traces of serious opposition were swept away by Newton. And as his great book appeared in 1687, we may, perhaps, take one hundred and fifty years as roughly the length of this important stage in the growth of astronomy.

The simple, lucid style, quite devoid of technical terms, and the short, well-spaced lines of type make for easy reading.

PAUL W. MERRILL
Mount Wilson Observatory
Pasadena, Calif.

WAXES

Adventures in Man's First Plastic. Nelson S. Knaggs. xiv + 329 pp. Illus. $6.75. Reinhold. New York. 1947.

THE subtitle of this book is "The Romance of the Natural Waxes." It is fully justified by chapters on Expedition to the Amazon (cauassu wax); Brazil's Tree of Life (carnauba wax); Exploring the Big Bend (candelilla wax); On to Mexico (candelilla wax); Submarine Treasure (whaling industry and spermaceti wax); The Little Lady Lac Bug (shellac wax); Ouricuri, The Ant Killer Tree (ouricury wax); The Esparto Harvesters of North Africa (esparto wax); The Mysterious Bee, Famine Fighter of Mankind (beeswax); A 60,000 Year Old Plastic (ozokerite wax); Wax from Ancient Forests (montan wax); and White Crystals from Black Gold (paraffin wax). There are many pages of rotogravure illustrations, a chapter on Wax Through the Ages, a short technical reference section on natural waxes, a bibliography, and an index, all testifying to the immense amount of work that has been put into the volume.

Besides accounts of beeswax and other insect waxes, there are stories of those obtained from the leaves of plants, from sperm whales, and from petroleum, lignite, and other deposits found in various parts of the world.

As the title implies, the book includes the fascinating history of ancient and modern man's search for these products, their extraction and processing, as well as the many uses made of waxes from the late Stone Age to the present time. An intimate picture is presented of various regions, the inhabitants, their beliefs, character, and their industries. Much information is interwoven with the stories of the waxes concerning the uses made, for example, of various parts of the carnauba palm, esparto grass, and whales. This information about the waxes and their uses is particularly good, but I noted that the unique liquid wax of the jojoba shrub (*Simmondsia californica*, Buxaceae) was not mentioned. I noted also that the bibliography does not list the book by H. Bennett, entitled *Commercial Waxes* (Brooklyn: Chemical Pub., 1944).

It would have been desirable to describe, as was done in the case of bayberry wax, the others which are also fats, including Japan wax, ucuuba, and that from murumuru palm kernels.

The book is very informative, however, and is written in a style that may be enjoyed by everyone.

GEORGE S. JAMIESON
Washington, D. C.

MAMMALOGY

Mammals of North America. Victor H. Cahalane. x + 682 pp. Illus. $7.50. Macmillan. 1947.

MR. CAHALANE sets out to summarize in popular form the existing information about the lives and habits of North American mammals. The result is a readable, charmingly illustrated book that should be of great interest to nature lovers, sportsmen, and the many country dwellers whose lives are affected by the activities of local wildlife.

Conspicuous forms are treated separately, less spectacular or more closely related ones, as groups. In general, each account includes figures on the reproductive cycle, care of the young, growth and development, shelter and nest building, mating activity, diet and the securing and storage of food, range and territoriality, seasonal activity, enemies, economic importance, and many odd and interesting bits of information about such things as singing in mice and the poison glands of shrews. Brief, general descriptions as well as ranges are also given. One of the most pleasing features of the book is the author's usually very successful attempt to make each animal a really living creature. In avoiding the dull and too-impersonal writing of many recent life histories, some of his humanizing strikes a false note, but in general the reader will feel that the different animals actually have a personality as well as habits and an appearance. In this respect his accounts of individuals, such as the story of a female cougar hunting deer at sundown, or of a young muskrat in the autumn searching for a home territory, are particularly successful. One of the most valuable contributions of the book is the discussion of the economic importance of various groups. The need to maintain a balanced population is well and convincingly stressed.

Both the text and the good, but admittedly incomplete, bibliography show a wide background of reading, though the sources of information are seldom given. In general, this makes for an easy style, well calculated to catch and hold popular attention, and when dealing with forms whose habits are well known the method is entirely satisfactory. Occasionally, when Cahalane is writing about less well-known forms or when he uses controversial material, the specialist would like to know the authority for certain statements.

A book of this sort should have a wide popular circulation, and it is a pity that the high price will inevitably limit it. Perhaps it would have been better to bring it out in two less expensive volumes.

BARBARA LAWRENCE
Museum of Comparative Zoology
Harvard University

ENCYCLOPEDIA

Van Nostrand's Scientific Encyclopedia. (2nd ed.) 1,600 pp. $12.00. Van Nostrand. New York. 1947.

SOME 11,000 topics, arranged alphabetically and elaborately cross-referenced, appear in the present edition of this one-volume encyclopedia. There are some 1,500 diagrams and photographs.

As in the first edition, the main fields covered are mathematics; the physical, earth, and biological sciences; the chief fields of engineering; and medicine. The format of the first edition has also been retained. But the number of contributing and consulting editors has risen from 21 to 40, and the number of pages from about 1,200 to 1,600. There are new sections on electronics, radio, metallurgy, meteorology, photography, and statistics. At least 1,000 entries have been added, and many of the original articles have been revised, often only in small details that nevertheless increase their accuracy and readability. Many articles have been expanded; a few—for instance, those on *Aerodynamics* and

Steel—are several times their former length.

The topics range from the most familiar—*Bedbug, Berry, Cement, Dog, Evaporation*, ...—to many that are highly technical—*Bernoulli probability function, Dynamical parallax, Gamma function, Pholidota*, ... Many of the topics are treated in only a few lines—for instance, those on *Lanceolate, Luth, Phimosis, Radiothorium, Veering wind*. Some cover half a dozen or more pages—as with *Algae, Amines and amides, Chemical composition, Hydrocarbons*.

Also as in the first edition, the treatment of most topics is progressive in difficulty, beginning with a simple definition or explanation and passing on to more detailed, technical considerations. As might be expected when different authors and different fields are represented, the treatments range from the fundamental and analytic to those containing mainly factual details. For only a few of the main fields are there articles that give a broad outline of the structure, branches, and chief characteristics of the field. Only for geology and chemistry are there separate articles on the histories of the sciences. However, the article on *History and evolution of chemistry*, in five and one-half pages, helps to make up for this deficiency in historical treatment of related fields by including a list of Nobel prize awards in physics, physiology, and medicine; by listing as developments in "pure chemistry" the work of Kirchhoff on black-body radiation, of Maxwell on electricity and magnetism, of Millikan on the electronic charge, and so on; and by putting under "applied chemistry" such items as Edison's development of the carbon filament lamp and De Forest's invention of the triode detector. Never should so patent an effort to further the unification of knowledge be allowed to pass unmentioned.

In reliability and comprehensiveness, this encyclopedia is far superior to the usual run of popular reference books. It is true that the responsibility for each broad field was in the hands of only one or two scientists, who had help from several consultants in the field. But as one result there is considerable unity among the many different articles in any given field.

The book should prove to be especially useful to college students of the sciences, to science teachers in the schools, and to educated laymen who need to have ready access to technical information.

DUANE ROLLER

Department of Physics
Wabash College

The Brownstone Tower

MUCH has been written and spoken about the responsibility of scientists to society. It is their responsibility, some people believe, to see to it that their new knowledge, which is power, is used only for beneficent purposes. In the August issue of the SM Professor Bridgman argued that scientists should not accept such responsibility, that they cannot do so and remain productive scientists. So far as "pure" scientists are concerned, Professor Bridgman is certainly right. It is ridiculous to suppose that the discoverer of a new principle could envisage all possible applications of it, and, even if he could foresee its detrimental potentialities, that he could prevent undesirable exploitations. Indeed, he may be in an honored grave long before his discovery has been made to plague society. Applied scientists, however, probably should do what they can, within reason, to control the use of their developments and inventions: through the patent system, through advice to industrialists and politicians, and through education of the public. But the real responsibility for the uses made of scientific developments must be placed upon society as a whole, of which scientists are a small part. Or one might say that our culture determines the course of science and the uses made of scientific discoveries. Individuals may really be helpless in the grip of our existing culture but, I think, they must act as if their efforts could direct its change toward desirable ends.

Assuming that education of the public not only transmits but modifies our culture, it should be desirable for both pure and applied scientists to report not only to fellow-scientists but to the general public, who, directly or indirectly, have made their work possible. It is not an exhibition of modesty but of selfishness when a scientist refuses to take the time or make the effort to keep the public informed about the progress and results of his work. He should cooperate with reliable news services. Large scientific societies, institutions, government agencies, universities, and industrial research laboratories employ writers to prepare reports of scientific progress for the press. It would be interesting to know to what extent these press releases are utilized. Certainly they serve to inform science editors and writers of much current progress and, if not used as written or rewritten, can lead to interviews and stories by science writers of newspapers and magazines. Whether he does or does not have the benefit of a press service within his own institution, agency, or society, a scientist should cooperate directly with professional science writers at every legitimate opportunity.

Of particular interest to us is the opportunity provided at A.A.A.S. meetings for cooperation between scientists and science writers. Every paper to be presented at the Chicago meeting should be made available to science writers through our press service in advance of the meeting in the form of an adequate abstract, complete manuscript, or both. The characteristics of an adequate abstract, from the point of view of a science writer, are described in this issue by Herbert B. Nichols, Science Editor of the *Christian Science Monitor.* Bear in mind, however, that some information delivered on time is better than complete information that comes late. I might add also that complete manuscripts thought suitable for publication

in the SM may be submitted to me well in advance of the meeting. Those accepted may be published early in 1948.

We should face the fact that science writers cannot make news out of every paper to be presented at the Chicago meeting. They know by experience the kinds of stories acceptable to their editors and, presumably, to the readers of their newspapers. Owing to the tendency of the public to personify every field of activity in terms of "stars," a few distinguished scientists have been well publicized. Their reports and pronouncements are therefore most newsworthy, and the science writers are most eager to get complete manuscripts of their addresses *in advance.* The work of other scientists who are not already known to the public is judged by its probable significance to public welfare and interest. Putting himself in the place of the lay reader, the science writer, examining a scientific report, asks: "How may it affect my daily life and thought? What does it mean to me?" Thus applied science is likely to be more productive of news than pure science, although pure science, insofar as it touches a philosophy of life or points to possible applications in war or peace, may have a great appeal. And finally there are the curiosities of science that are sufficiently within the experience of laymen to be called interesting for their own sake. Although his work may seem to have no popular significance, let no scientist assume that it is without news value. If he will prepare his abstract as recommended by Mr. Nichols and deliver it on time, he may be surprised to find that there is a story in it for science reporters. If not, he will have the satisfaction of having done his best to report back to the public.

Those who have time to read books written by scientists probably get the clearest and most comprehensive view of the development and significance of scientific work. Our Assistant Editor, Mrs. Keener, who has been in charge of our Book Review section for the past year, is publishing reviews of the more popular scientific books as they appear. The present issue is to be regarded as our Winter Book Issue. Planned largely by Mrs. Keener, it features articles on special scientific libraries, just as the Spring Book Issue emphasized the work of the university presses. Hereafter, however, we expect to have but one book issue each year, probably in the fall. In addition to presenting a special theme concerning scientific books, each book issue will contain articles relating science to the humanities; e.g., Bradford Willard's article in this issue on "The Geology of Shakespeare."

The December issue of the SM may well be called the Convention Issue. Chicago is certainly one of the most important scientific centers in the United States. It is a center not only of scientific research but of scientific education through its universities and museums. The December issue will inform the reader of the wealth of scientific activity in the Chicago area, with particular emphasis on the new research institutes of The University of Chicago. Special articles by Chicago scientists will complete the issue. We hope that our Convention Issue will help to draw to Chicago the largest group of scientists that ever attended an A.A.A.S. meeting. There is much to see and learn in Chicago. Remember the dates—December 26–31, 1947—and request your hotel reservations now!

F. L. Campbell

THE SCIENTIFIC MONTHLY

VOL. LXV — December 1947 — NO. 6

SCIENCE IN CHICAGO

By JEANNETTE LOWREY *et al* *

Miss Lowrey, Senior Assistant, Department of Press Relations, The University of Chicago, and Chairman of the Publicity Committee of the Chicago meeting of the A.A A.S., was requested by the Editor to describe some of the scientific institutions in the Chicago area Her article and those of her collaborators follow in alphabetical order of the names of the several institutions. Articles about the three new Institutes of The University of Chicago, written by their Directors, are published separately in this issue.

THE CHICAGO ACADEMY OF SCIENCES

The Chicago Academy of Sciences, founded in 1857 for the promotion and diffusion of scientific knowledge, is the oldest scientific organization in Chicago. The founders of the Academy included many of the men who helped to build the city of Chicago: James V. Z. Blaney, Nathan S. Davis, Sr., James W. Freer, Henry Parker, J. Young Scammon, Franklin Scammon, Richard K. Swift, Joseph D. Webster, Eliphalet W. Blatchford, and Henry W. Zimmerman. The first headquarters on the corner of Clark and Lake streets soon were outgrown, and the collections were moved to the Metropolitan Block, where fire seriously damaged them. In 1868 a fireproof museum building was erected at 263 Wabash Avenue. It was unique among museums of the time. The disastrous Chicago fire of 1871, however, completely destroyed this building and the priceless collections it contained. From 1873 until 1892 the collections of the Academy were on display at the Interstate Exposition Building in Grant Park, where the Art Institute now stands. In 1893, through the generosity of Matthew Laflin, the present building was constructed in Lincoln Park at Clark Street and Ogden Avenue. The museum is supported by private endowment, gifts, memberships, and by a share of the museum tax allotment distributed by the Chicago Park District.

The museum presents the natural history of the Chicago region, past and present, and brings to the public other scientific exhibits of current interest. Lifelike habitat groups show the animals in their natural setting along with the herbs, flowers, and trees with which they are usually associated. The scenes range from the lake shore

* Those who collaborated with Miss Lowrey are as follows. Eliot C Williams, Jr, The Chicago Academy of Sciences, Jean McArthur, Chicago Medical Society; John R. Millar, Chicago Natural History Museum; Lewis M Glassner, Chicago Technical Societies Council; James W. Armsey, Illinois Institute of Technology; Mary Kay Jones, Mundelein College; Norb Hildebrand, Museum of Science and Industry; Edward Stromberg, Northwestern University; C. Lincoln Williston IV, University of Illinois.

MUSEUM OF NATURAL HISTORY, THE CHICAGO ACADEMY OF SCIENCES

north of Chicago to the Indiana Dunes and show, in addition to the animals that may be found there now, many others that were once residents but that, for one reason or another, are no longer present. The magnificent whooping crane, whose resounding cry once boomed over the marshes surrounding the city; the white-tailed deer, which browsed in the forest that once covered the region; the gulls and terns, which wheel and soar over the bustling traffic of the Michigan Avenue bridge—these are but a few examples of the many animals on exhibition.

The larger vertebrate forms are not the only ones shown in habitat groups. The insects, too, are represented in their natural environment. To mention only a few, one may see hibernating insects, slave-making ants, burying beetles, and a swarm of migratory monarch butterflies.

The habitat groups, because of their nature, cannot include all the animals and plants native to the Chicago region. A systematically arranged series of almost 400 birds, however, gives the bird lover a convenient opportunity to check the identification of any bird he might see Nests and eggs of some of the more common species of birds are also shown. Representative examples of the hundreds of kinds of insects that may be found in this part of the country and some of their life histories may be seen in the museum.

For those interested in the Chicago area of long ago, there are exhibits of fossil plants and animals. Four large relief maps trace the changes that occurred in Lake Chicago, the large glacial lake that remained after the recession of the last glacier, resulting in our present Lake Michigan. Examples of the rocks and minerals are

available to those interested in the geology of this region.

The Atwood Celestial Sphere, the only one of its kind in the world, is a reproduction of the sky over Chicago. It is a rotating hollow shell of thin sheet metal on which the stars are represented by perforations of different sizes. Within this sphere, unhampered by the light of the sun, moon, or freak illumination, or by inclement weather, it is possible to study the constellations for any season of the year or any hour of the day. The sphere was effectively used for courses in navigation by the Naval Reserve training school at Northwestern University during the war. Elementary and high-school classes also make use of the sphere.

The museum is used by many school classes in their study of natural history. Members of the staff conduct the groups through the museum and present lectures in the auditorium, using the Academy's motion pictures and lantern slides. Several amateur and professional societies are affiliated with the Academy and hold their meetings at the museum. At the present time the affiliated societies are: State Microscopical Society of Illinois, Illinois Audubon Society, Chicago Entomological Society, Marquette Geologists Association, and the Burnham Astronomical Society. The Chicago Herpetologists Club also meets in the Academy building.

Not on public exhibition, but available for the use of qualified students, are the scientific study collections consisting of approximately 14,000 skins of birds and mammals, 10,000 specimens of amphibians and reptiles, 80,000 insects and other invertebrates, and many specimens of rocks, minerals, and fossils.

During the fall and winter months of the year a series of free public lectures is offered on Sunday afternoons in the auditorium of the museum building. The lectures deal with various scientific subjects, travel, explorations, and other aspects of natural history. Many of the lectures are given by well-known authorities in their field and are accompanied by colored slides or motion pictures. Discovering new facts and relating them to human welfare are two important phases of the museum's responsibilities. Although it is not possible for the Academy to give major emphasis to scientific research, members of the staff are endeavoring to do a share of this work commensurate with the amount of time and facilities available.

Serial publications include *The Bulletin of the Chicago Academy of Sciences*, containing technical studies by members of the Academy and the museum staff; *Natural History Miscellanea*, short articles in several fields of natural science, *The Chicago Naturalist*, a nontechnical quarterly; *Studies of the Natural History of the Chicago Area*, devoted to local problems; and *Special Publications*, book-length treatises or others that do not fit into the preceding series.

Field work in the vicinity of Chicago is carried on almost constantly for the purposes of obtaining material for exhibits and adding to the knowledge of the local flora and fauna. When funds are available, expeditions are made to more remote regions in North America for collecting specimens and carrying on scientific studies in natural history. In recent years a number of expeditions have been made to the Southwest, especially the desert regions of Arizona, for the purpose of taking motion pictures and adding to the collections of reptiles, birds, mammals, and invertebrates.

CHICAGO MEDICAL SOCIETY

Chicago Medical Society, organized April 19, 1850, is the largest county medical society in the country, with a membership of approximately 6,300 representing most of the physicians in Cook County. It is divided into 15 branch organizations made up of the physicians in the various sections of the city. There are also 20 affil-

iated societies representing the different specialties of medicine.

The Society is noted for its contributions to the growth and welfare of the city of Chicago, for the part it has played in improving medical education and medical schools in Cook County, and for its education programs, not only for its own members but for other physicians and the general public.

The parent society and each branch organization hold monthly meetings for members. For some years the Society held regular open meetings for the benefit of the citizens of Chicago. During the two years of the Century of Progress International Exposition, the Society scheduled physicians to speak on popular health topics each day in the Hall of Science. Following the opening of the Museum of Science and Industry, the Society has furnished 4 to 8 physicians each year to address public meetings sponsored by the Museum.

Four years ago the Society established the Annual Clinical Conference, an intensive postgraduate course for the general practitioner. Three such meetings have been held, with a large attendance of Midwestern physicians. Hundreds of outstanding medical teachers and scientists have participated in the programs of these conferences.

Plans have been completed for the Society to sponsor short postgraduate courses on medical specialties for doctors of the country. Two of these courses were given in the fall of 1947.

The Society is now working on plans for the publication of a weekly bulletin to be called "This Week in Chicago Medicine." It will inform resident and visiting physicians of current events in the medical schools and hospitals of Chicago.

The Society is represented in many of the civic organizations of Chicago; e.g., Council of Social Agencies, Chamber of Commerce, and Adult Education Council.

CHICAGO NATURAL HISTORY MUSEUM

FOUNDED by a group of civic leaders and endowed by the late Marshall Field as the Field Columbian Museum of Chicago to preserve and develop the mass of natural-history material brought together from all parts of the world by the World's Columbian Exposition of 1893, Chicago Natural History Museum, under the guidance of Mr. Stanley Field, its longtime President, has become in the course of the past fifty-four years, one of Chicago's outstanding institutions, and is now one of the largest natural-history museums in the world.

The fundamental division in museum organization followed by Chicago Natural History Museum provides exhibition collections and reserve (or reference) collections. This is a reflection of a basic duality of interest, in (1) *general education*, which requires a limited number of well-labeled or ingeniously devised exhibits, and in (2) *research*, which requires the vastly greater number of specimens in reference collections. This dichotomy runs through much of the staff of this as of other museums, with scientists and their aids engaged in research and also in the planning of exhibits and supervision of artists and artisans assigned to their preparation. The existence of a research institute in every large museum as a fundamental part of its organization is not well known, even among many groups of scientists. The scientists in this Museum are engaged primarily in description and classification, basic aspects of their respective sciences. That these aspects form the foundations of natural history, and that they have been neglected in America to a disproportionate degree, has become evident in recent decades and is a matter of great concern to Chicago Natural History Museum.

Museums and those universities in which

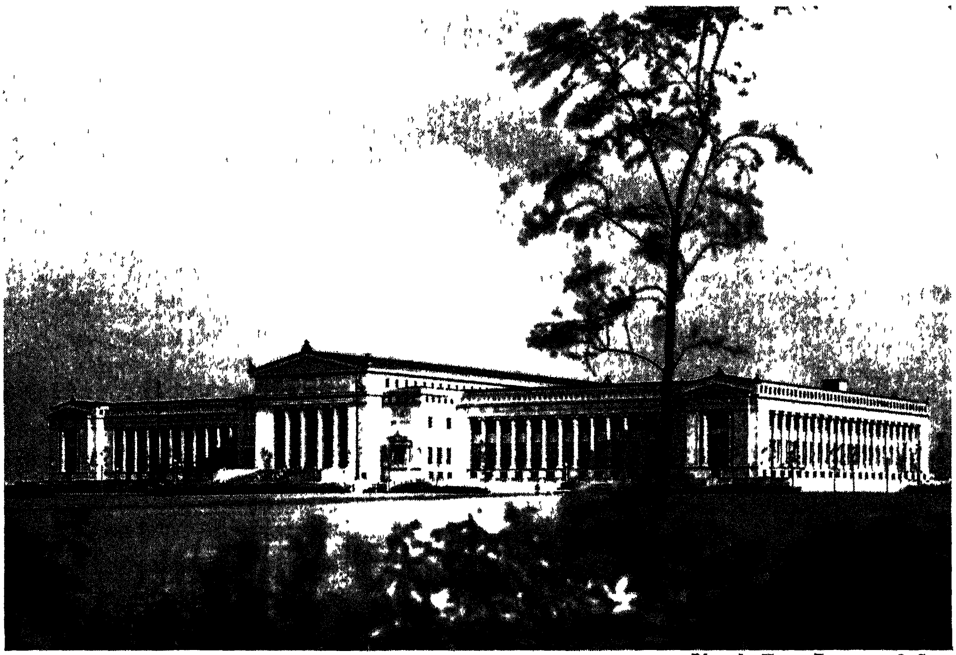


Photo by Henry Fuermann & Sons

CHICAGO NATURAL HISTORY MUSEUM

UNTIL NOVEMBER 23, 1943, IT WAS KNOWN AS THE FIELD MUSEUM OF NATURAL HISTORY.

museum work still finds appreciation and support especially need to present the possibilities for effective expansion of these types of research. Expansion of exhibition is limited by the walls of the museum building. It should be limited also by another factor—the capacity of the visitor to absorb information, "museum fatigue" being well recognized by psychologists as a special type of tiring of the feet and mind in combination.

Growth of the reference collections may be limited by available space and curatorial staff; but the research activities in the descriptive sciences are capable of very great development. Such expansion of systematic zoology and botany, including especially paleontology, is now essential for the sound growth of the associated sciences. Opportunities for important and interesting research in these directions are endless, and their pursuit is stressed at this Museum.

Department of Anthropology. Underlying the Museum's research in anthropology are its anthropological collections, numbering some 300,000 specimens, and its extensive library of anthropological literature. The collections cover every major area of the world. Particularly outstanding are those in the fields of North American ethnology; archeology of North, Central, and South America; ethnology of Africa, Oceania, and Indonesia; and archeology and ethnology of China. The Melanesian collection is probably the largest and most representative in the world.

During the past ten years scholarly activities in the Department of Anthropology have fallen under four headings: field research, the acquisition of additional collections, the production of scientific reports based on field research and on the study of the Museum's collections, and exhibition work. In spite of the suspension of field work during the war years, nine anthropological expeditions—to Southwestern United

STANLEY FIELD HALL

THE GREAT CENTRAL HALL LEADING TO THE EXHIBITS OF THE CHICAGO NATURAL HISTORY MUSEUM.

States, Ecuador, Peru, and the Marshall Islands—were sent out during the ten-year period.

The recent policy in adding to the anthropological collections has been restrictive and selective. In general, only specimens accompanied by adequate data as to origin and function, which fill serious gaps in the existing collections or are important to the Museum's research program, have been acquired. This policy is appropriate to the needs of a mature museum and to the present status of anthropological research.

Anthropological research in the Museum during the past ten years has been in the fields of North American ethnology, North and South American archeology, ethnology of Oceania and China, anthropology of Africa, archeology and anthropometry of the Near East, and anthropometry of Melanesia. The results of these studies have been published by the Museum and in various scholarly journals.

During the past six years the Department of Anthropology has carried out an extensive exhibition program, directed primarily toward the installation of a new Hall of American Archaeology. The program has involved not only continuous research in new exhibition methods and techniques, but varied anthropological research as a basis for the preparation of the exhibits.

During the war the volume of anthropological research was reduced by the absence of staff members taking part in the war effort. During this period the Department carried out work for the Committee on African Anthropology of the National Research Council. This committee furnished information on Africa and personnel lists to the various war agencies. The Department also cooperated with the Aero Medical Research Laboratory at Wright Field in producing models of physical types used in designing oxygen masks for the Army Air Forces.

Department of Botany. In accordance with the general policy of the Museum, the Department of Botany sponsors two principal fields of activity. One, devoted to public instruction, is concerned with the planning and preparation of exhibits consisting of prepared botanical material and products, supplemented by photographs, paintings, models, and reproductions of plants. The exhibits are displayed in five halls designated, respectively, as Hall of Plant Life, Food Plants, Economic Plants, American Woods, and Foreign Woods.

The other field of activity comprises the acquisition, through botanical expeditions, exchange, and purchase, of botanical collections and their care and scientific study. The phanerogamic herbarium is particularly rich in tropical American material. Similarly, the cryptogamic herbarium is made up of large collections representing all groups of lower plants (algae, fungi, lichens, and mosses), but is especially well known for the extensive representation of fresh-water algae. A special collection of American and Old World palms ranks among the finest of its kind in completeness of the collected material and the aids provided for critical study. A large file of hand samples of woods, representing mostly tropical trees and shrubs, is maintained as a separate reference collection; the accompanying herbarium specimens are incorporated in the phanerogamic herbarium. Special collections of economic plants and plant products are also available for reference and purposes of identification. The combined collections of all kinds total more than a million specimens.

The file of photographs of type and other historically important specimens of American plants, mainly deposited in the great European herbaria, now contains about 40,000 negatives. As many of the priceless original collections were destroyed during World War II, these negatives represent the

AN ANDEAN VALLEY AT THE TIME OF THE INCAS

DIORAMA IN MINIATURE, RECENTLY PLACED ON EXHIBITION IN THE HALL OF NEW WORLD ARCHAEOLOGY AT THE CHICAGO NATURAL HISTORY MUSEUM. IT SHOWS THE TYPICAL TERRACED FARMS, AN IRRIGATION SYSTEM, A SUSPENSION BRIDGE, AND A STONE FORTRESS OF THE EARLY INDIANS OF PERU.

only records in existence. The inestimable value of this collection is generally conceded.

In addition to many special studies and monographs of certain groups, the Department of Botany is engaged in the publication of several large floras, notably the *Flora of Peru*, *Flora of Guatemala*, and the proposed floras of Ecuador and middle Central America.

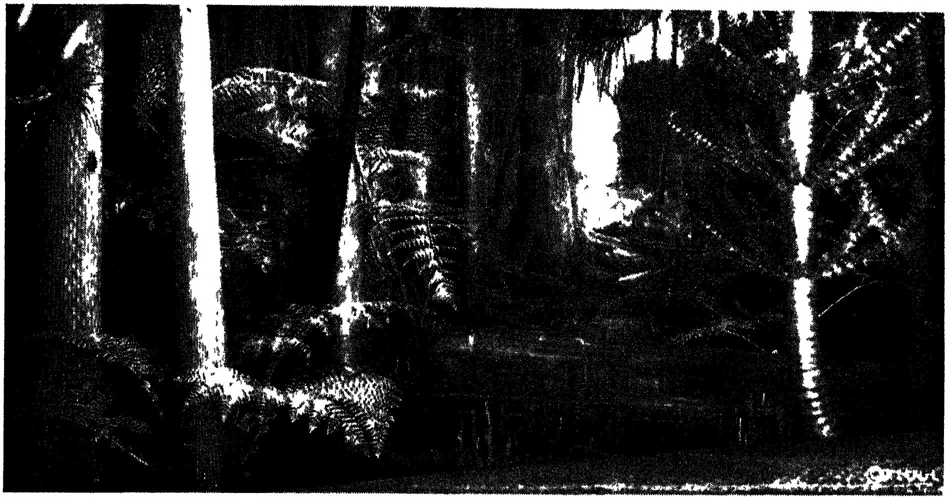
During the recent war several members of the staff served in various advisory capacities to governmental agencies or were sent abroad by the Board of Economic Warfare.

Department of Geology. The exhibits of the Department of Geology represent most of the fields of this science, the display of vertebrate fossils being especially fine. In this hall, it is the policy to show a limited number of specimens to the best advantage, with a small painting of the restored animal in its natural habitat accompanying each mounted skeleton, and a brief explanatory label in place of the close-printed essay of the older cases. Emphasis in the past has been on displaying as much of the collection as could be crowded into the cabinets. The current program of exhibition involves extensive revision of this material.

The real strength of the Department lies in its reference collections and in the work continually being done with them by members of the staff Field trips are planned with reference to research needs, and representation in fields of active investigation is continually expanded according to current requirements. In the past few years, important additions have been made in this

WELWITSCHIA PLANTS IN MOSSAMEDES DESERT

NEW HABITAT GROUP IN MARTIN A. AND CARRIE RYERSON HALL AT THE CHICAGO NATURAL HISTORY MUSEUM, SHOWING A RARE AND STRANGE PLANT FOUND ONLY IN SOUTHWEST AFRICA.

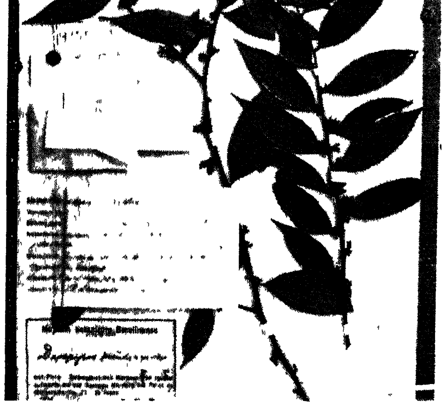


A CARBONIFEROUS FOREST OF 250,000,000 YEARS AGO
ONE OF THE FAMOUS EXHIBITS AT THE CHICAGO NATURAL HISTORY MUSEUM

way in connection with the work being done on arctic Ordovician faunas, turtle classification and evolution, Paleocene mammals, the Mazon Creek flora of the Pennsylvanian, minerals, and metamorphic rocks.

The meteorite collection is unusually fine, more than 70 percent of the known falls being represented. Study of the meteorites is facilitated by a sectioning saw and chemical laboratory on the premises. A revised catalog of the meteorites is now in preparation for publication. In the collection of invertebrate fossils are many of the amazingly well-preserved Mississippian crinoids from now-depleted localities in Indiana and Iowa and a large number of specimens from Patagonia and Newfoundland, collected on past expeditions and still in part unstudied. An X-ray laboratory and a staff of preparators assist the study of the vertebrate fossils, in the collection of which there are many scientifically valuable type specimens of primitive mammals, early birds, turtles, and crocodiles, described by staff members. A cooperative arrangement with The University of Chicago has opened the collection of fossil vertebrates to University classes.

Department of Zoology The growth of research in systematic zoology in Chicago Natural History Museum is reflected in its



A TYPE SPECIMEN
PHOTOGRAPHS LIKE THIS, MADE FOR THE CHICAGO NATURAL HISTORY MUSEUM BEFORE THE WAR, ARE NOW THE ONLY RECORDS OF TYPES DESTROYED BY BOMBING. THIS SPECIMEN WAS IN BERLIN.

AFRICAN WATER-HOLE GROUP AT THE CHICAGO NATURAL HISTORY MUSEUM

collections and in its publications. These collections have grown from the original nucleus of mounted specimens exhibited by Ward's Natural History Establishment at the World's Columbian Exposition of 1893 in two directions—specimens on exhibition now filling more than 13 halls on the ground floor and first floor of the building; the even greater growth of the research collections has filled available space on the third and fourth floors. The estimated number of objects on exhibition is about 8,000; the estimated number of specimens in the research collections has long since passed the 1,000,000 mark. The scientific staff in zoology alone has grown in fifty years from 4 to 14 members, and the technical papers produced by them compose some 50 volumes The Museum's zoological collections have pre-eminence in certain special fields, especially those of tropical America and South America generally, but have been kept in the main at a level of world-wide interest and world representation.

CHICAGO TECHNICAL SOCIETIES COUNCIL

SIGNIFICANT of the growing spirit of cooperation among technical men is the Chicago Technical Societies Council, which today, in its fourth year, includes 51 local sections of national scientific, engineering, and technological societies. Local membership of these societies exceeds 18,000.

Under the direction of a full-time staff at 53 West Jackson Boulevard, Chicago, the Council maintains a broad program of activities aimed to further cooperation among the affiliated societies, to provide means for more effective public service by the societies and their members, and to make the community more fully aware of the contributions of these men to community life and betterment.

Executive Secretary of the Council is Paul A. Jenkins, who is also serving as Chairman of the Local Committee on Arrangements for the December 1947 meeting of the A.A.A.S. President of the Council for the 1947–48 year is Dr. Gustav Egloff, Research Director of Universal Oil Products Company.

The Council owes its inception to the war-inspired spirit of close cooperation among all agencies of science, research, engineering, and technology for the purpose of defeating a common enemy. Early in 1943 the War Production Board conceived the idea of sponsoring a series of conferences throughout the United States to provide a means for "swapping" ideas contributed by science, engineering, technology, and management as an aid to war production.

The Chicago War Production Clinic, held on March 11, 1943, at the Medinah Club, was the largest such conference held in the United States.

The local venture was fostered by the War Production Board with the aid of the Chicago Section of the American Society of Mechanical Engineers and 16 other engineering and technical societies of the Chicago area. Following the outstanding success of the 1943 conference, an organizing committee was formed to prepare a prospectus with the purpose of establishing a permanent Chicago Council. On September 2, 1943, the first official meeting of the Chicago Technical Societies Council was held, with 37 representatives of 23 societies in attendance. Officers and directors were elected at this meeting, and the chairmen of 11 committees were appointed

The Charter Roster of affiliated societies closed at 33 members in November 1943. The Council was formally incorporated under the General Not for Profit Act on February 28, 1944. Under the financing plans of the Council, it was stated that there would be no charges or fees to constituents of the Council and that none of its participants were to receive salaries. Income was to be derived from the following sources: publication of *Sci-En-Tech News*, the monthly bulletin of the Council; periodic publication of a directory of scientific, technical, engineering, and research men and facilities in the Chicago area; and Council-sponsored conferences and exhibits. There were to be no dues or assessments.

With its financial plans formulated and its organizational structure completed, the Council set forth to increase its membership and to fulfill its primary purposes of promoting Chicago as the leading scientific and technological center of the world, and of stimulating production and employment in the city and its surrounding area.

In early 1947 the membership had increased to include 51 societies, with a Council membership of 18,000 engineers, scientists, and technologists. Member-societies represent many fields of activity and include, for example, The Society for Experimental Biology and Medicine, the American Chemical Society, the Western Society of Engineers, The American Institute of Architects, The Industrial Management Society, the Institute of Radio Engineers, The American Society of Mechanical Engineers, the American Pharmaceutical Association, The Instrument Society of America, and the Society of Plastic Engineers

An annual high light of the Council's activities is the Chicago Production Conference and Show, which, in March 1947 at the Stevens Hotel, was attended by more than 27,000 people. The 1947 Conference presented 86 speakers contributing to 35 panel sessions held during the three-day clinic. In addition, exhibits by 130 suppliers of tools, materials, equipment, and services were displayed for the benefit of executives interested in the broad trends of production techniques and in the industrial development of the Chicago area.

Slightly overshadowed by the annual Production Show and Conference are the many other activities engaged in by the Council and incorporated in its aims and purposes. A representative of the Council sits on the Mayor's Commission for School Board Nominations, which supplies the Mayor with names of citizens to fill vacancies on the School Board. The Council supplies vocational-guidance panels to technical high schools for the benefit of young men who are going on to advanced training in the sciences and technologies. The Council collaborates each spring with the Museum of Science and Industry in conducting a series of free lectures on technical subjects of interest to the public. Public and private libraries are represented on the Council's Library Committee, to the end that technical holdings will be of

greatest possible value to technical men and to the community. The Council is compiling a directory of research facilities in this area as a means of furthering the use of modern research methods by Chicago corporations and institutions.

The Council cooperated in the placement of returning Army and Navy veterans in jobs calling for engineering, scientific, and technical degrees. More than 700 veterans have been processed through the Council's office since V-J Day. In cooperation with the State Department, the Council sponsored a public meeting publicizing the objectives of the United Nations Educational, Scientific, and Cultural Organization. In programs of adult education, the Council works closely with such institutions of higher learning as The University of Chicago, Northwestern University, and Illinois Institute of Technology.

The Council's monthly publication, *Sci-En-Tech News*, is the central source for information about the monthly meetings of the 51 affiliated societies. The publication also contains information of general value to technical men.

The economic status of the members of the affiliated societies is the concern of the Council's Employment Committee, which regularly reports to the societies news of legislative and other developments affecting the employment status of the individual.

The Council's Speakers Bureau serves local club and church groups by providing qualified speakers on technical subjects. Allied with this activity are the speech courses run by the Council for the benefit of technical men who feel that their educational experience has failed to develop adequate abilities in the field of self-expression.

The Council's Program Committee is concerned with the quality of the monthly meetings of the affiliated societies and encourages cooperation among program chairmen to attain cross-fertilization.

ILLINOIS INSTITUTE OF TECHNOLOGY

ILLINOIS INSTITUTE OF TECHNOLOGY was formed July 24, 1940, through the merger of Armour Institute of Technology and Lewis Institute. The former had been established in 1892, the latter in 1896. The development program of the new institution was hardly underway when the country was plunged into war. Illinois Tech moved immediately into a vast, accelerated wartime training program.

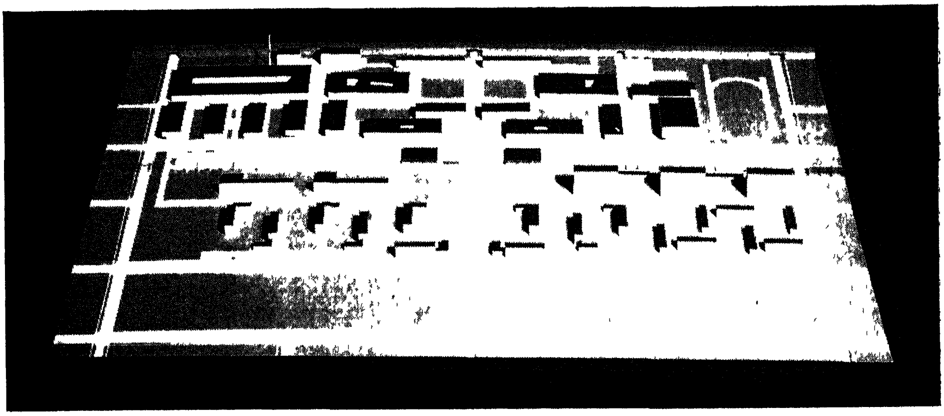
Total war prevented the Institute from immediately consolidating its educational position. However, its own temporary sacrifice enabled it to furnish 60,000 trained specialists to the Army, the Navy, and industry.

Peace for Illinois Tech meant not only reconversion problems in education, but a resumption of the educational solidification and the physical development the war had interrupted.

Major attention, aside from that directed strictly to matters of education and research, is focused on a long-range, much-needed building program. With slight exception, the Institute's building program was necessarily dormant during the war. Now it is going ahead rapidly.

When the two schools merged, the Lewis campus was located on Chicago's near West Side, and the Armour campus on Chicago's near South Side. For the wartime period this division of locations continued. Moreover, courses were given at other locations throughout the city. All are now centered on one campus with the exception of two departments, which are still housed near the Loop, but these eventually will move to the new location.

Illinois Tech's official address is 3300 Federal Street. The general area is one of the portions of Chicago slated for an extensive program of urban redevelopment. The Illinois Tech development will eventu-



THE FUTURE ILLINOIS INSTITUTE OF TECHNOLOGY
A PLOT PLAN SHOWING HOUSING (*foreground*) AND CLASSROOM AND RESEARCH BUILDINGS (*background*).

ally comprise about 105 acres. It will include buildings for education and research, and housing for students, staff, and faculty. It will extend from Thirty-first to Thirty-fifth Street and from South Michigan Avenue to the New York Central railroad tracks.

Three of the new functional buildings designed by Ludwig Mies van der Rohe, internationally known architect and head of Illinois Tech's Department of Architecture, have been completed. Two have been assigned to, and are being used by, Armour Research Foundation, the industrial research unit of the Institute. One has been assigned to the school's Naval Reserve Officers' Training Corps. A large building to house the Chemistry Department and one to provide new quarters for chemical engineering and metallurgy are nearing completion. Five war-surplus temporary buildings are in use for classes and for necessary adjunct services.

Work carried on at Illinois Institute of Technology is conducted by three units: the educational unit, with its undergraduate and graduate schools; Armour Research Foundation of Illinois Institute of Technology, specializing in industrial research; and the Institute of Gas Technology, which provides graduate education for the gas industry and conducts fundamental and applied research applicable to industry problems.

THE educational unit of the Institute now consists of three divisions, the College of Engineering, the Division of Liberal Studies, and the Graduate School. It also includes an Evening Division, in which both credit and noncredit courses are available in each of the areas of study.

Until three years before the consolidation of Armour and Lewis institutes, neither had a graduate school. In 1937 the Graduate School at Armour was established under the supervision of a dean. After the merger, one of the major objectives was to enlarge, develop, and strengthen the Graduate School. Although this program was slowed by the war, it was never halted. Since the war, it has been given increased emphasis. Today, graduate courses leading to master's and doctor's degrees are available in engineering and science.

Armour's College of Engineering was started with four-year courses in mechanical and electrical engineering. In 1895 Armour Institute and the Art Institute of Chicago established the Chicago School of Architecture, now Illinois Tech's Department of Architecture. Other engineering courses

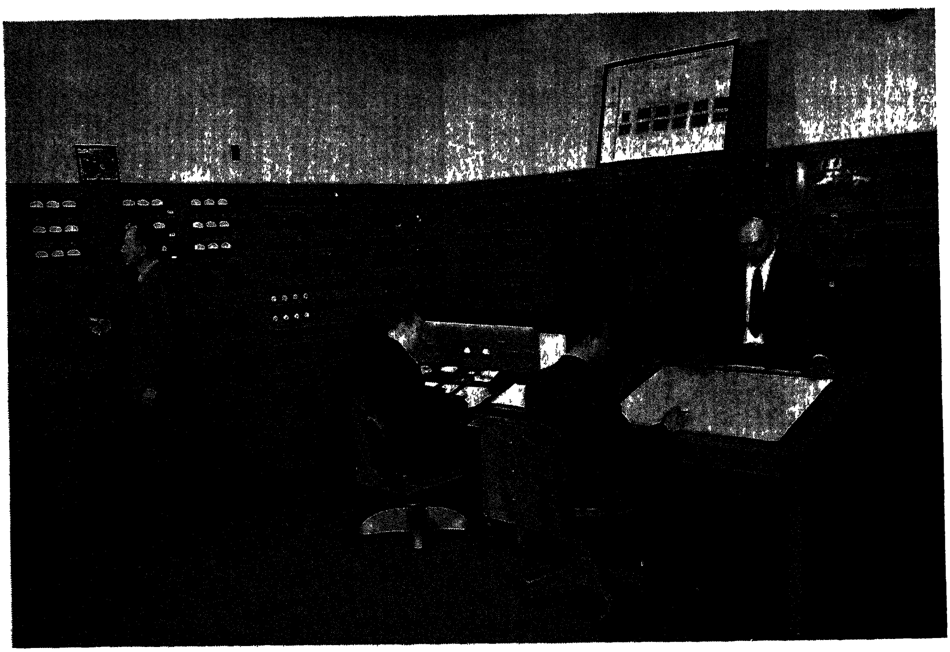
were established around the turn of the century and on to 1946, when the latest, metallurgical engineering, was started. A course in fire protection engineering, started in 1903, is still the only four-year course in this field given in any college in the United States.

Lewis Institute began as an academy and a junior college. Shortly thereafter it offered a four-year engineering course, granting the first degree in 1901. In 1912 it began to grant degrees in home economics. The degree in arts and sciences was first conferred in 1918, at which time the academy was discontinued. The arts and sciences courses became a part of the curriculum after the formation of Illinois Tech. In 1945 a special Division of Liberal Studies was established. The end of the war has brought a great expansion to this Division, which offers a complete liberal arts program. Illinois Tech is often thought of as a strictly engineering school for male students. On the contrary, it is coeducational in enrollment and offers a wide assortment of courses in liberal arts and sciences for both men and women.

Before World War II, Illinois Tech's daytime enrollment was about 2,200, with approximately 2,500 in the Evening Division. Current enrollment is 3,300 in the day courses and 4,000 in the Evening Division. The faculty has increased almost 100 percent since the end of the war.

Research of a fundamental nature is supported by grants of Institute funds or by contributions from outside sponsors. Applied research projects with completely specified objectives are in general handled by Armour Research Foundation.

In addition to research carried on by all departments, special laboratories are maintained for work in corrosion, photoelasticity, mechanics, fluid flow, catalysis, electron microscopy, spectroscopy, hearing, heat transfer, power systems engineering, electronics, engine noise, nucleonics, psychology, and biology.



THE A-C NETWORK CALCULATOR

IN THE ARMOUR RESEARCH FOUNDATION OF ILLINOIS INSTITUTE OF TECHNOLOGY.

In September 1936, three men with an idea, a purpose, and a capacity for hard work moved into three ground-floor rooms in the old Armour flats. Thus, with one project, an industrial research organization, later to be known as Armour Research Foundation of Illinois Institute of Technology, was founded.

From this rather inconspicuous beginning, the Foundation has grown rapidly, until today it has eight research divisions and one service division. These divisions, housed in various offices and laboratories, have completed more than 7,000 research projects for some 1,900 companies, government agencies, and trade and professional associations.

The Foundation is a nonprofit corporation, with the same trustees and officers as Illinois Tech, founded to render a research and engineering service to industry. Industry-sponsored research projects are accepted in confidence, with all patent and publication rights transferred to the sponsor.

Competitive projects are not accepted. Staff members are not permitted to do outside consulting or industrial advising and are under patent-waiver agreement to the Foundation.

One of the chief contributions of the Research Foundation is in the field of magnetic wire recording. It was here that the recorder was invented and developed.

Undergraduate or graduate students are not employed on industry-sponsored research projects. However, a limited number of Foundation-sponsored industrial research fellowships are available, combining a graduate educational program at the Institute with experience and training in industrial research techniques at the Foundation.

More than 150 research projects are now active in applied mechanics, ceramics, chemistry and chemical engineering, electrical engineering, mechanical engineering, metals, and physics. In addition to well-equipped laboratories in each research division, the following special laboratories and services are maintained:

- National Registry of Rare Chemicals
- Riverbank Acoustical Laboratory (Geneva, Ill.)
- A-C Network Calculator Laboratory
- Ohmite Laboratory of Precision Electrical Measurements
- Precision Gage Laboratory
- Armour Magnetic Recording Laboratories
- Glessner House Laboratories of Lithographic Technical Foundation
- Poulter Laboratory of High Pressure Research
- Metals Heat Treating Laboratory
- Welding Research Laboratory

Projects in fundamental research now in progress and supported by the Foundation are: high-pressure phenomena, transformer insulation, electromagnetic measurement of torque, crystallographic studies, stress corrosion, residual stresses in metals, anechoic chamber, hardenability measurements, abrasion resistance, magnesium alloys, diffusion in alloys, solidification under pressure, vacuum treatment of metal, and magnetostriction.

The Institute of Gas Technology at Illinois Institute of Technology was founded in 1941 to serve the gas industry in education and research. It was organized as a nonprofit corporation to specialize in scientific instruction and research pertaining to the production, distribution, and utilization of gas and its by-products.

Control of the Gas Institute is vested in a Board of Trustees composed of 22 men, 17 of whom are selected from candidates designated by member-companies. The remaining 5 are chosen by the Board of Trustees of Illinois Tech.

Research problems are considered under two headings, depending on whether the project is of recognized importance to the gas industry. If so, then all patents must be available royalty-free to members of that

industry; if not, the sponsor has full rights to any patents resulting from the project, except that the Institute retains a shop right.

Research projects now active include: fundamental study of reactions of carbon, oxygen, and steam at high temperatures and pressures; improvement of gasoline lantern and mantle; pilot-plant study of hydrocarbon reforming; partial devolatilization of coals in fluid bed; general study of flash pulverization; sulfur-resistant catalyst study; oil gasification in fluidized bed; organic sulfur in gas; gasification of coal and coke fines; flash pulverization of mineral ores; flash pulverization of coal; investigation of fly ash; autodestructive alkylation of propane; oil research; and high-pressure research.

MUNDELEIN COLLEGE FOR WOMEN

SINCE Mundelein College for Women is a small, liberal arts college, it has neither the facilities nor the backing to carry out extensive scientific research. Consequently, the aim of Mundelein's Science Department has always been directed toward improved undergraduate instruction, liberal in scope, but in practice preprofessional.

With this idea in mind, the administration has approved the set-up of equipment in the science laboratories considered the best in undergraduate schools in this locality.

The entire sixth floor is devoted to completely equipped science laboratories comprising two large chemistry laboratories, two physics laboratories, zoology, botany, geology, astronomy, embryology, and bacteriology laboratories.

Of special interest and value in the Science Department is a 120-foot Foucault pendulum, by which the rotation of the earth may be demonstrated and measured. Swinging nine stories in an otherwise unoccupied elevator shaft, the pendulum, longest of its kind in existence and only one of its kind, so far as is known, to have its movement recorded by an electric spark, is used by the Physics Department and is available to specialists in geophysics and astronomy and to others interested in scientific research. Besides recording the precession of the earth, the pendulum enables the Physics Department to keep a permanent record of the value of the gravitational constant for the Chicago area.

MUSEUM OF SCIENCE AND INDUSTRY

"SCIENCE DISCERNS THE LAWS OF NATURE: INDUSTRY APPLIES THEM TO THE NEEDS OF MAN."

THIS inscription, in bold relief around the rotunda of the Museum of Science and Industry in Chicago, epitomizes the purpose and achievements of this huge institution dedicated to the service and education of the public.

Below the inscription is a huge periodic table of elements, majestic symbol of man's physical resources—"the building blocks of nature." Radiating from this central court are the huge halls and galleries and beyond them the lesser halls and rooms devoted to man's progress in fitting the elements to his needs. Here are re-enacted the great historic experiments of science, and beside them whirr and throb the wheels, the pistons, the gears, and levers of application. More than 8 acres of dynamic working exhibits are gathered here for man to see, to wonder at, to ponder over, and, above all, to understand.

A visit to the Museum is a visit to another world—the world of knowledge, where the past rubs shoulders with today and steps on the heels of tomorrow. For this is the Museum's purpose—to provide the link of understanding between the ivory towers of

MUSEUM OF SCIENCE AND INDUSTRY

science and the smoke-stained chimneys of industry.

The visitor, on his first acquaintance with the Museum, is apt to find the introduction a bit startling. As he approaches, he is impressed with the majestic simplicity of the structure. Erected originally as the Fine Arts Building for the Columbian Exposition of 1893, the structure is based on the Greek classic as applied to a modern plan.

The effective use of Ionic columns, modeled after those of the Erechtheum, one of the temples on the Acropolis, provides an air of classic dignity and simplicity to a building which extends its front over 1,146 feet and provides a total floor area of around 14 acres.

Passing through the huge bronzed doors at the entrance, the visitor is suddenly engulfed in a world of light and color, space and sound. On either side of the north court in which he stands, and leading to the rotunda, are the massed colors of the nations of the world.

To his left and right open the wide entrances of the lesser halls. To the rear, immediately behind the periodic table, rise the superstructures of a coal-mine tipple and an oil derrick. From all sides come the noises of machines and the hubbub of milling throngs of visitors.

Despite the vastness of the spatial dimensions, there is an air of informality and intimacy the new visitor immediately senses. This is not a museum where one whispers through musty corridors to view endless glass cases of exhibits. Here the accent is on visitor participation. He may check his packages free. He may smoke. He may talk as loudly as he pleases. And above all, he finds, as he strolls along, that he may become a part of the show.

Here he finds a modern Midwest farm in full size. He may wander through the barn and look at the five types of dairy cattle in this country—life-size. He may walk through the fully equipped toolroom, through the dairy barn, or the farm kitchen. Or he may relax in the farm living room and view from a comfortable seat the display of field equipment at work in the surrounding fields.

In another section—devoted to steel—the visitor may see an old-time blacksmith

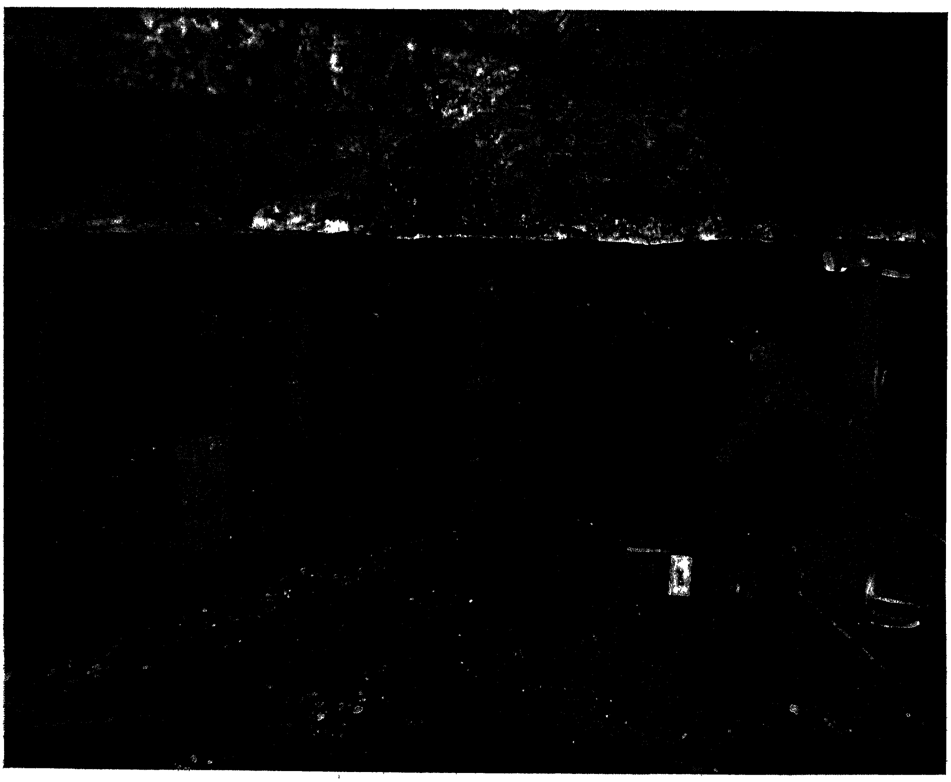
shop, again full scale, and at times even watch a blacksmith making nails here, for the philosophy of the Museum is not simply exhibition—it is demonstration as well. Continuing with the story of steel, the visitor finds a modern welding booth in operation and a working foundry where he may watch an actual "pour." During the war, this foundry produced a considerable amount of war material through such daily demonstrations.

Once the visitor has passed through the entrance doors, he will find himself the victim of a restless urge—the desire to see all there is to see in this trip. About halfway through the day he will finally conclude that he'll never make it—there's too much to see in a single visit. The best way is to concentrate on the things of specific interest and later see other exhibits.

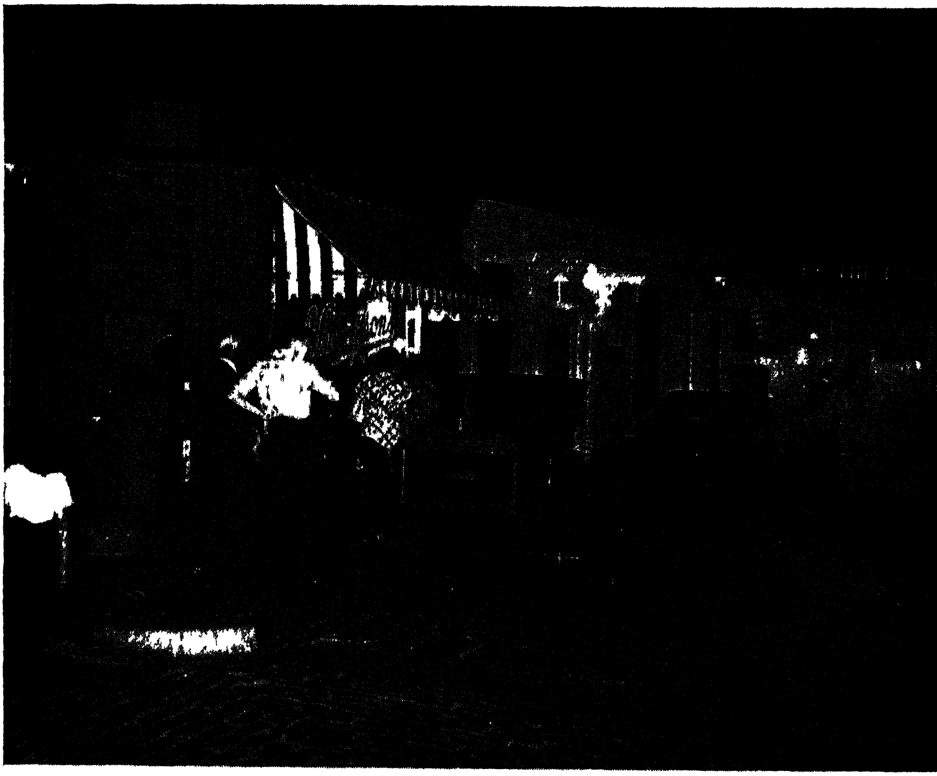
The Museum is arranged in sections, each section being devoted to a broad field, and this in turn is broken into specific phases of that field in smaller sections. Transportation, for example, is one of the broad subjects. In one room, the history of transportation is developed in terms of the automobile, ranging from the "surrey with the fringe on top," vintage of 1904, to a 16-cylinder modern car. In an adjoining room, or hall, railroad transportation is covered with not only the early types of locomotives, but a miniature railroad representing one of this nation's largest railroad systems.

In a new exhibit, currently being constructed, the visitor will see the evolution of the automobile in terms of component parts such as brakes, tires, self-starter, etc.

In a life-sized replica of a street of 1910,



COAL MINE
REPRODUCED IN THE MUSEUM OF SCIENCE AND INDUSTRY.



MAIN STREET, 1910
REPRODUCED IN THE MUSEUM OF SCIENCE AND INDUSTRY.

the visitor himself becomes a part of the exhibit. Here he may inspect the fashions of that age in the shopwindows, see what early Chicago stores looked like, and view an old-time movie in the Nickelodeon.

Still studying transportation, the visitor can trace the history of sea travel through accurately scaled ship models ranging from the early Phoenician to the modern ocean liner. He may even launch a model ship himself in the Marine Room.

The history of aviation is another part of transportation. Models of famous planes, as well as the historic planes themselves, tell the story. Exploded models of motors, in operation, reveal the poetry of motion found in the complexity of the modern airplane power plant. Radar is explained so that the visitor may see how it operates to safeguard the airways of the nation.

In another section of the Museum, the story of petroleum is revealed, from the formation of the oil under the earth's surface millions of years ago to its conversion to gasoline—lifeblood of the nation—as well as other by-products.

In the field of basic science, the visitor may become acquainted with physics and perform many of the experiments that led the way to modern industrial miracles. He may see how the earth turns and observe the conversion of energy; he comes face to face with Newton's laws of motion, to make understanding as easy as an apple falling off a tree.

The story of radio shows how energy becomes music and voice; and in the telephone exhibit the visitor finds out not only how a telephone works, but how he himself sounds over the phone. There is a section

"THE MIRACLE OF GROWTH"

EXHIBIT PROVIDED BY THE UNIVERSITY OF ILLINOIS FOR THE MUSEUM OF SCIENCE AND INDUSTRY.

devoted to magnetism, to electricity, to optics. There are lectures and demonstrations, moving pictures, and equipment the visitor operates. There are full-size models and miniatures. There are dioramas and habitat groups—all devoted to one purpose—all there to tell a story.

Last year, 1,500,000 people attended the Museum. This year attendance is expected to be over 2,000,000. The average visit is three hours; the average group is a family. As many women as men come to the Museum, for there are special exhibits that attract each sex.

One of the latest exhibits is devoted to the growth and development of a human being, from conception to adulthood. It is in effect a frank, simple, dignified presentation of the "facts of life" and represents an outstanding contribution to the field of public-health education.

The Museum is a place of constant change. Major Lenox R. Lohr, President, summarizes the basic philosophy thus:

> We are not a repository for old relics As soon as an exhibit has lost its educational value, as soon as the story it has to tell is outmoded, we dispose of it regardless of our personal feelings. We believe that only by constant change and improvement can we keep pace with the scientific discoveries of today and their industrial applications. Our mission is to interpret these things for the benefit of the public, and in so doing, we make more clear and better appreciated the American way of life.

NORTHWESTERN UNIVERSITY

NORTHWESTERN UNIVERSITY'S facilities for science are located on its Chicago campus in the Medical and Dental schools and on the Evanston campus in the new Technological Institute and the College of Liberal Arts departments of Chemistry,

Physics, Zoology, Botany, and Geology.

The Evanston campus. The greatest impetus to work in science at Northwestern has come in the past ten years, with the founding and development of the new Technological Institute. A magnificant Lannon stone structure with 10 acres of floor area and 2 miles of corridors, the building of the Technological Institute houses the departments of Electrical, Civil, Mechanical, and Chemical Engineering of the Institute, as well as the Physics and Chemistry departments of the College of Liberal Arts.

A gift of $6,735,000 by Walter P. Murphy made possible the establishment of the Technological Institute in 1939, and his bequest in excess of $25,000,000 two years later ensures its maintenance and development. The study program of the Institute is conducted on the cooperative plan, by which a student spends part of his educational time in school and part as an industrial worker.

The Department of Physics occupies approximately 110 rooms in an L-shaped wing in the southwest part of the Institute building. Laboratories and classrooms are on the first and second floors. Special installations such as the compressor for liquefaction of air and hydrogen, X-ray equipment, generator rooms, shops, and special research rooms are on the basement floor. Third-floor rooms are set aside for research projects.

A three-year program of fundamental physics research now in process is expected to lead to new and improved communication devices. It is an extension of wartime research, in which Northwestern physicists developed a new invisible-ray telephone and many new types of photoelectric cells used in the phone and in Army and Navy secret weapons. Among other projects being developed in the Physics Department is an infrared spectrometer, which records or measures atomic emission spectra in the near infrared beyond the range of photography. The spectrometer is designed particularly to go from 1 micron to 4 or 5 microns of wave length.

The Department of Chemistry, with quarters in the east front and southeast wing of the Institute building, is equipped to accommodate more than 600 students. Provision for exceptionally tall equipment, such as a controlled distillation column, is made by a shaft 75 feet high and 10 feet square, extending from the subbasement to the top of the building. At each floor level the walls of the shaft are provided with laboratory service.

Experimental work in catalysis and chemical reactions at high pressure, which was inaugurated at Northwestern a decade ago by Dr. V. N. Ipatieff, is carried out in a suite of specially designed rooms, including a separate bomb room and a room for gas analysis. Chemical experiments are made here in rotating bombs up to very high pressures. Extensive laboratories serve the Organic, Analytical, Inorganic, and Physical Chemistry divisions. To construct apparatus for chemical research, a well-equipped Glass-blowing Department is operated in the basement.

Among the subjects and fields being studied in this Department are the isotopes of oxygen, thermodynamics of high polymers, reaction kinetics with special emphasis on specific heats of gases, interraction of proteins with ions, steroid chemistry, wave mechanical equations, magnetic properties of matter, reactions under high pressure, organic chemistry of catalysis, pyrolysis and studies in carbohydrate and thiophene chemistry, catalytic hydrogenation, polarographic analysis and reaction mechanism, synthesis of pyridinium compounds, and reaction mechanics.

The northwest wing of the Institute building contains the Department of Civil Engineering. Available for undergraduate instruction as well as research are large

MAIN ENTRANCE, TECHNOLOGICAL INSTITUTE, NORTHWESTERN UNIVERSITY

THIS SECTION OF THE BUILDING CONTAINS LIBRARIES, OFFICES, AND EXPERIMENTAL ROOMS USED BY ALL DEPARTMENTS OF THE INSTITUTE. THE BUILDING CONTAINS 454,000 SQUARE FEET OF FLOOR AREA.

testing machines, the most powerful of which is a 5,000,000-pound hydraulic press, used for testing the strength of concrete columns and other members of dams and bridges.

A 1,000,000-pound hydraulically operated transverse universal testing machine is in the center of a large well in the civil engineering wing. In the cement and concrete laboratories investigative work is conducted independently or in cooperation with industry. Three special-temperature rooms are adjacent to the cement laboratory: a freezing room tested to a temperature of −55° F., an airtight dry room arranged to produce any temperature or

humidity approximating outside conditions, and a moist room designed to maintain a relative humidity of 100 percent at a temperature of 75° F.

Research being done includes the fatigue testing of materials and the problems of soil mechanics.

In the 28,000 square feet occupied by the Department of Chemical Engineering in the south-central wing are included such laboratories as unit operation, metallurgical research, furnace and ceramics, physicochemical measurements, and crushing and grinding. An exceptionally complete filtration section includes an Oliver filter, a Sweetland pressure filter, a Shiver plate and frame filter press, and a basket centrifuge.

The Department is now engaged in research in gas absorption that may lead to better methods of preparing certain important chemicals. A new method for storing natural gas in liquid form is being perfected in chemical engineering. It reduces storage space by more than 99.8 percent In other experiments finer sizes of coal are cleaned by a Humphreys spiral (formerly used for recovering only heavy ores), and elimination of fine particles from wash water by a cyclone separator. This separator ordinarily is applied only to gases and liquids with larger precipitates.

The entire north-central wing, the Department of Mechanical Engineering, rests on separate foundations to prevent vibrations from being communicated to other parts of the building. This Department has been doing extensive work on the study and design of artificial limbs for the Army. Among other research going on in this

Hedrich-Blessing Studio

A LABORATORY IN PHYSICAL CHEMISTRY, NORTHWESTERN UNIVERSITY

WARD BUILDING, NORTHWESTERN UNIVERSITY, CHICAGO CAMPUS

THIS BUILDING HOUSES THE MEDICAL AND DENTAL SCHOOLS OF NORTHWESTERN UNIVERSITY

Department is the study of air compressors for use in gas turbines.

Electrical engineering is in the northwest wing of the building, occupying about 32,000 square feet of floor space. The electrical machinery laboratory is in the basement near the power sources. Electronics, electrical measurements, and most of the communications laboratories are on the second floor. The high-voltage laboratory, 2 stories in height, occupies the end of the wing. The voltage of the impulse equipment is higher than any other in the Chicago area.

Among the research projects underway in the Electrical Engineering Department are those in the following fields: aerial measurements and specialized computing procedures, microwave theory related to wave guides and lens systems, closed-

cycle control systems, analogue-type computing machines, and cold cathode power tubes.

The Chicago campus. Northwestern University has embraced a forward-looking program in medicine. A $100,000,000 medical center is now being established on the Chicago campus at Lake Shore Drive and Chicago Avenue. Already located on the campus are the Medical and Dental schools and two affiliates of the Medical School, Passavant and Wesley Memorial hospitals. It is expected that the completion of the project will require twenty-five years.

Key structure in the planned new development will be an Institute for Medical Research to supplement clinical and research facilities of the campus and serve as the initiating and coordinating agency for a vast program of medical research. Another project proposed for the new center is an Institute of Geriatrics, which will undertake investigation in the field of degenerative diseases and the problems of aging.

Erection of a clinical and research unit is assured through a bequest of $1,500,000 from the late Mrs. Joy Morton. The Veterans Administration soon will build on the Chicago campus a 600-bed cancer hospital, which will be the finest institution for the study of cancer in the world.

Work is being done in seventeen different fields of medical research, including pathology, surgery, pediatrics, nutrition, ophthalmology, urology, dermatology, bone and joint diseases, and malignant diseases.

PROPOSED INSTITUTE FOR MEDICAL RESEARCH, NORTHWESTERN UNIVERSITY

A proposed Department of Aeronautical Medicine will study the countless new medical problems posed by aviation, such as altitude and pilot fatigue. Occupational diseases and other health hazards in industry will be investigated by a newly created Department of Industrial Medicine.

Extensive research is being carried on in the fields of respiration, vascular disease, cancer, and congenital heart disease. Other research now in progress includes the study of streptomycin as a treatment for tuberculosis and development of an improved electronic instrument, a fluorimeter, which will increase the range and depth of chemists' research.

The University has recently established an Institute for the Study of Rheumatic Fever, the first such institute in any school of medicine in the nation. Its laboratories are housed on one entire floor in the Municipal Contagious Disease Hospital in Chicago.

A Department of Nutrition and Metabolism was established this year under the chairmanship of Dr. Tom D. Spies, internationally known authority in nutrition. The University hopes to develop, in conjunction with the Spies committee, the nation's broadest program of research in nutritional diseases.

The Medical School proper occupies the first seven floors and the eighteenth-floor tower of the Montgomery Ward Building, and the Dental School, the eighth to the thirteenth.

Working closely with the Medical School, the Northwestern Dental School is equipped with modern clinics conducted by the departments of Operative Dentistry, Prosthetic Dentistry, Oral Pathology, Children's Dentistry, Orthodontia, Diagnosis, and Oral Surgery and Radiology.

Principal research has dealt with dental caries, diseases of the gums, and materials used in dentistry. A service that has expanded since the war is that of training dental hygienists as auxiliary personnel to work in the dental office and in public-school dental-health programs.

DURING the war many of Northwestern's facilities were used in thirteen different types of war training programs for the Army, Navy, and Marines, and for civilians in war industries. Of the 49,225 total attendance, 36,124 were Naval trainees, with 6,210 trained in the Navy Radio Operators' School on the Evanston campus and 26,570 in the Reserve Midshipmen's School, including the Commissioned Officers' Indoctrination School on the Chicago campus. The Navy V-12 and Navy R.O.T.C. in Evanston trained 2,338.

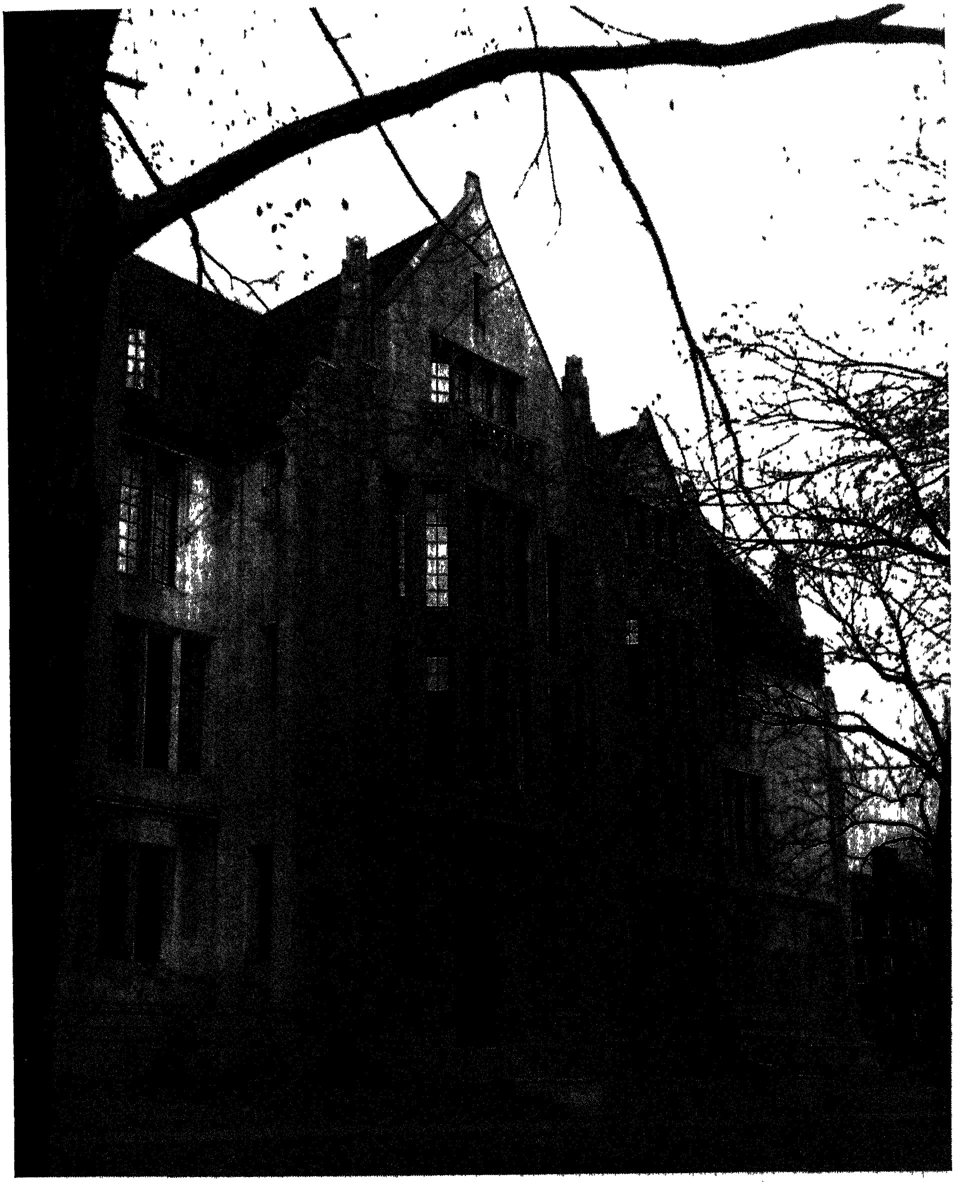
Other programs conducted for the armed forces were Civilian Pilot Training and Navy Flight School, Army, Navy, and Marine Reserve programs, Army Signal Corps, Army and Navy medical and dental programs, and the Army Civil Affairs Training School.

War research also was extensive, with fifteen different government projects being carried on in the physical sciences, five in chemistry, four in physics, three in electrical engineering, and one in mechanical engineering. War research was done by the Medical School on twelve different projects of its own, in physiology, neurology, and surgery.

THE UNIVERSITY OF CHICAGO

THE following account of scientific research at The University of Chicago stresses wartime accomplishments. The present work of the three institutes that have sprung from the Metallurgical Laboratory is described on pages 482–94.

The atomic bomb. During the war years The University of Chicago was one of the major centers of the war-research program. In this capacity it acted as host and contracting agency for the Metallurgical Labor-



ECKHART HALL, UNIVERSITY OF CHICAGO

THIS BUILDING, WHICH HOUSES THE INSTITUTE OF NUCLEAR STUDIES AND THE DIVISION OF PHYSICAL SCIENCES, WAS A CENTER DURING THE WAR FOR RESEARCH LEADING TO DEVELOPMENT OF THE ATOMIC BOMB.

atory, now the Argonne National Laboratory, where fundamental investigations underlying the development of the atomic bomb were carried out. An idea of the magnitude of the University's war effort is provided by the budget figures for the year 1944–45: an income of $32,390,945, and a total staff of 8,000, approximately half of whom were engaged in government work.

The Metallurgical Laboratory was a large part of this effort and had associ-

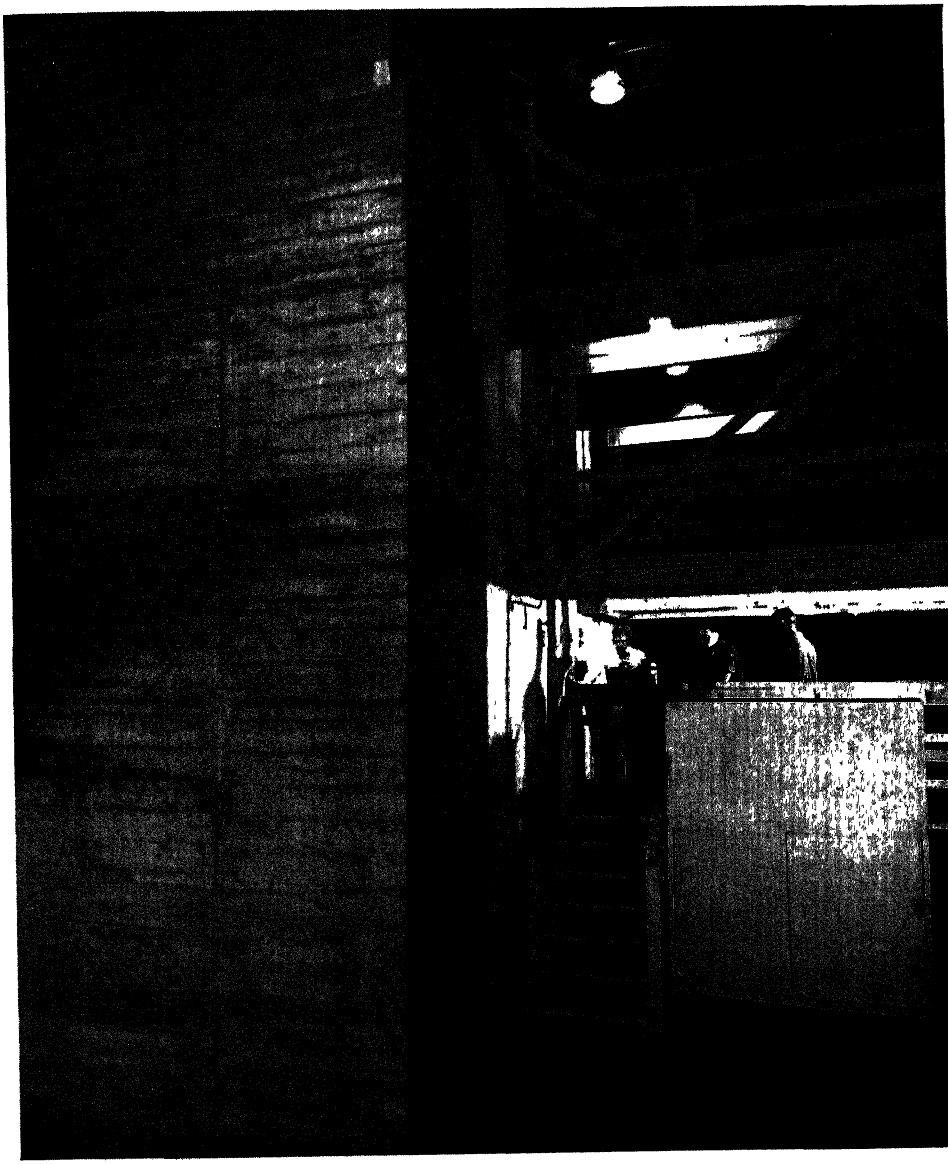
ated with it other installations in or near Chicago. Until June 30, 1945, the University administered the Clinton Laboratories at Oak Ridge, Tenn., designed and operated by E. I. du Pont de Nemours & Company, making use of the experience obtained in the Metallurgical Laboratory. Both the Metallurgical Laboratory and the Clinton Laboratory assisted the Du Pont Company at the production plant at Hanford, Wash.

The Metallurgical Laboratory was first carried on under the auspices of the Office of Scientific Research and Development and later under the Manhattan District of the Army Engineers. The atomic age began December 2, 1942, when Enrico Fermi, Nobel prize winner and now Charles H. Swift Distinguished Service Professor of Physics at the University, and a small group of physicists achieved release of atomic energy in a self-maintaining nuclear chain-reaction pile in a squash-racquets court in the West Stands of Stagg Field. Operated at a low level, this pile served as the prototype of a pilot plant at Oak Ridge, Tenn., and of the vast production plant at Hanford, Wash. The Argonne National Laboratory is now being operated by the University for the Atomic Energy Commission on a basis that permits participation by the staffs of 25 universities and other research organizations in the Middle West interested in nuclear research. Walter H. Zinn, Associate Professor of Physics at the University, is Director of the Argonne.

Although the Metallurgical Laboratory engaged the services of most of the members of the University's Department of Physics and Chemistry, it was fundamentally a great cooperative effort of the Army, scientists of American universities and

WEST STANDS, STAGG FIELD, UNIVERSITY OF CHICAGO

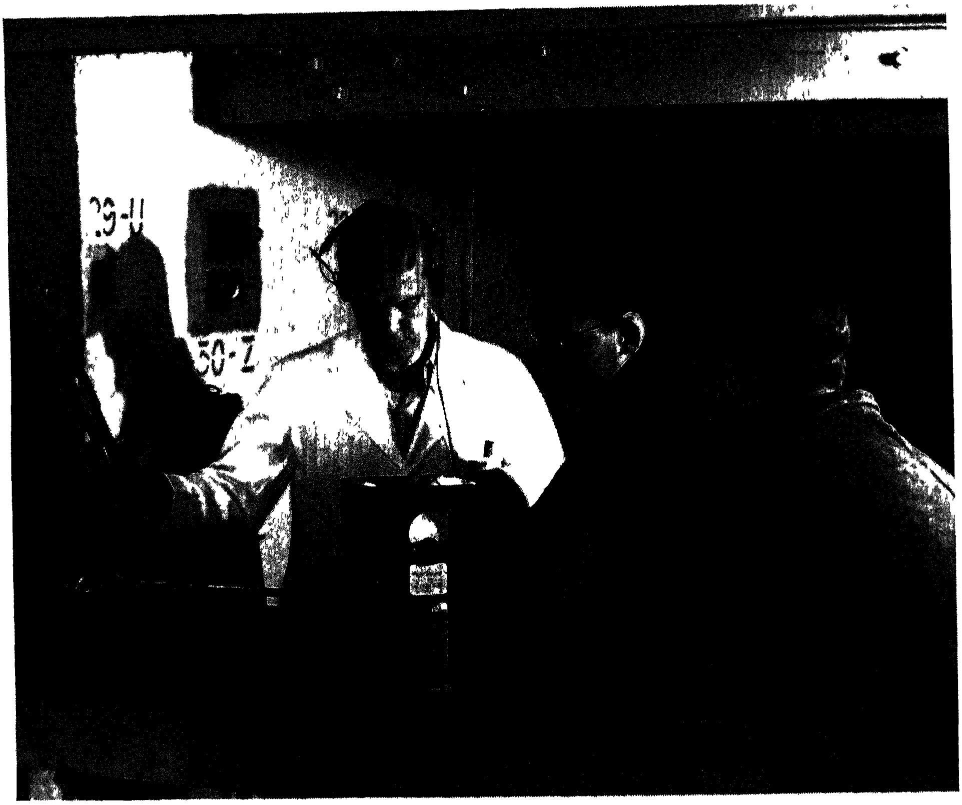
THE FIRST NUCLEAR CHAIN REACTION WAS DEMONSTRATED HERE ON DECEMBER 2, 1942.



A URANIUM PILE, ARGONNE NATIONAL LABORATORY, PALOS PARK

THIS PILE IS THE REASSEMBLED ORIGINAL PILE FROM STAGG FIELD A CORNER OF THE SHIELDING WALL IS SHOWN HERE. THE BALCONIES CARRY THE CONTROL RODS THAT OPERATE THE PILE. THE OPERATORS ARE ABOUT TO PUSH INTO THE PILE A SAMPLE TO BE IRRADIATED.

industrial organizations, engineers, industry, and public agencies. Members of the Metallurgical Laboratory, in addition to their key achievement of the self-sustaining pile, determined the chemical properties of plutonium, devised a method for its chemical separation from uranium and fission products, and in general solved the problems involved in mass production of plutonium. All this work was carried on with submicroscopic amounts of plutonium, by means of "tracer" chemistry. The step



SCIENTISTS AT THE ARGONNE NATIONAL LABORATORY

A CLOSE-UP OF THE OPERATORS SHOWN IN THE PREVIOUS PHOTOGRAPH ALSO ILLUSTRATES A SAMPLE MADE RADIOACTIVE IN THE PILE AND THE RECORDING EQUIPMENT ALWAYS USED TO BE SURE THAT THE OPERATORS NEVER EXPOSE THEMSELVES TO DANGEROUS AMOUNTS OF RADIOACTIVITY.

from this laboratory study to the design of the Hanford Works based on it was of the order of ten billion times. In the Laboratory, Dr. Glenn T. Seaborg, of the University of California, and others identified two new transuranic elements, numbers 95 and 96.

Biological warfare. While the physical scientists were exploring in the atomic field, the botanists of The University of Chicago were commissioned by the Chemical Warfare Service of the U. S. Army to arm the nation against a biological war.

Initial research on plant controls for crop destruction resulted in 1941 at the beginning of the war from a suggestion made to the Secretary of War by Ezra J. Kraus, Chairman of The University of Chicago's Department of Botany. Dr. Kraus, a pioneer in the use of synthetic growth-regulation substances, foresaw the possibility of the enemy's using compounds for herbicidal purposes against the Allies. Experiments carried out at the University under his direction provided unequivocal proof of the herbicidal activity of many growth-regulating substances.

Crop- and weed-destructive properties of 1,100 different chemical agents, which would have been used to lay waste food supplies of the enemy had he resorted to biological warfare, but which also have great benefits for peacetime agriculture, were investigated by the Chemical Warfare

Service of the U. S. Army in laboratories at The University of Chicago, The Ohio State University, Camp Detrick (Frederick, Md.), and the U. S. Plant Industry Station (Beltsville, Md.). Research at the University was conducted in Hull Botanical Laboratory directly across the street from the plutonium laboratory, where the basic secrets leading to the production of the atomic bomb were developed.

Although biological warfare was not used in military operation in World War II, the botanists reported that enough information was discovered on the possibilities of plant destruction to show that it is imperative that the nation be alerted on methods of use of such compounds and methods of combating their ill effects.

The rapid ending of the war prevented field trials, in an active theater, of the synthetic agents, which would have, without injury to animal or human, affected certain growing crops. The same principles, however, are now being applied to destroy noxious weeds throughout thousands of acres of pasture land in the Western states and growing fields of sugar cane, rice, pineapple, and other crops.

Application of certain of the 1,100 organic compounds tested by the Laboratory could have deprived the enemy of numerous crops—the loss of which would sometimes have been discovered only after cultivation.

A wartime chemical—isopropylphenylcarbamate—first used in Great Britain, and especially toxic to grasses, was found to kill field-grown winter rye and to seriously damage grown oats when the compound was applied to the soil in sawdust at seeding time.

Young cabbage plants, soybeans, tomatoes, sweet potatoes, and sugar beets, sprayed with 2,4-dichlorophenoxyacetic acid (first used as a growth-regulating compound by Professor Kraus) were killed or stunted in growth with amounts as low as 0.1 pound applied to a single acre.

Bacteriology and parasitology. During the war, the Department of Bacteriology and Parasitology cooperated with the Department of Biochemistry in investigations on the metabolism of malarial parasites. This work has been continued in the Department under the direction of Dr J. W. Moulder, Instructor in Biochemistry, and has been broadened to include studies on the metabolism of trypanosome and helminth parasites. Special emphasis is being placed on the effect of the immune reactions of the host upon the metabolism of the parasite.

Dr. W. H. Taliaferro, Eliakim H. Moore Distinguished Service Professor of Parasitology and Chairman of the Department, is continuing his investigations on the mechanism of immunity against the animal parasites. He is at present particularly interested in the cellular basis of immunity and in the effect of X-rays and the nitrogen mustards in reducing immunity in experimental malaria.

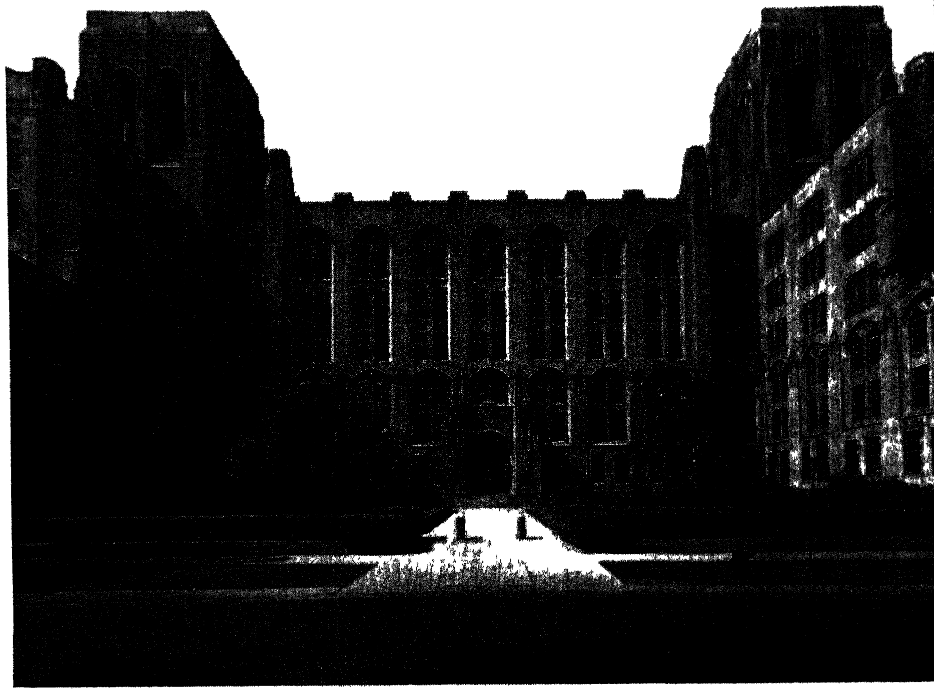
Beginning before the war and continuously since, Dr. Clay G. Huff, Professor of Parasitology, and his associates have concerned themselves with the exoerythrocytic stages of various malarial parasites. They have demonstrated the tissue stages of four species of avian malaria which precede the development of the stages in the blood. The behavior of these stages in immunity and under the influence of drugs has been studied.

Dr. Stewart A. Koser, Professor of Bacteriology, is conducting experiments on bacterial nutrition, with particular emphasis on the vitamins and their relation to microbic activities.

Dr. William Burrows, Associate Professor of Bacteriology, is studying the nature of effective immunity to infection with the cholera vibrio and other enteric bacilli.

Dr. F. B. Gordon, Associate Professor of Bacteriology, is conducting research on infantile paralysis and other diseases of the central nervous system caused by viruses.

The physiological characteristics and



ALBERT MERRITT BILLINGS HOSPITAL, UNIVERSITY OF CHICAGO

pathogenicity of the nonsporulating anaerobic bacteria, particularly those associated with puerperal fever, are being investigated by Dr. K. Eileen Hite, Instructor in Bacteriology. Recent or current investigations by graduate students working with Dr. Hite have been concerned with the conditions for production of enterotoxin by, and the effect of antibiotics on, food-poisoning staphylococci and the antibiotic activity of certain molds against Brucella.

Pathology. During the war, Dr. Paul R. Cannon, Chairman of the Department of Pathology, and members of the Department concentrated on studies of protein nutrition in relation to infection and resistance and on problems of amino acid metabolism in relation to health and disease. These studies have led into investigations concerning cancer, nutrition, wound healing, vitamin needs in relation to protein synthesis, and the like. During the war Dr. C. C. Lushbaugh, Instructor in Pathology, was active in the study of the effects of nitrogen mustard, out of which came the use of this substance in the treatment of certain neoplastic diseases. Dr. Paul E. Steiner, Associate Professor of Pathology, during the past decade has been studying the problem of cancer-inducing agents that may be present in human tissues. Dr. Eleanor M. Humphreys, Professor of Pathology, has investigated vascular diseases, particularly rheumatic fever, and other diseases of connective tissues.

Pharmacology. Early in 1941 the Department of Pharmacology, under the chairmanship of Dr. E. M. K. Geiling, began to cooperate in two wartime projects: the Toxicity Laboratory for the study of chemical warfare agents and the Antimalarial Project for the study of potential drugs for the treatment of malaria. The Toxicity Laboratory is continuing under

the sponsorship of the U. S. Army. The present work of the "Tox Lab" will be described in a later issue of the SM.

The malaria research problem was sponsored by the O.S.R.D. Committee on Medical Research. More than 1,000 compounds were studied for their antimalarial activity and acute and chronic toxicity. Experiments on the intermediate metabolism of drugs were also carried out, especially with quinine and atabrine. One of the metabolic products of quinine was isolated for the first time Identification of its structure led to the synthesis of a large number of potentially valuable compounds.

Since the war, this Department has undertaken research projects for the U. S. Navy in anesthesiology and for the U. S. Public Health Service in chemotherapy and drug metabolism. The pharmacology of a number of new drugs is being investigated. Work on the application of radioisotope technics to pharmacology is well underway.

Zoology. In a general way, the research activities of the Department of Zoology fall into five broad categories: embryology, physiology of reproduction, genetics, evolution, and ecology

Embryology is represented by Professor Paul Weiss and Assistant Professor Ray L. Watterson. Dr. Weiss and his students work primarily on problems associated with the development of the nervous system in vertebrates, especially amphibians. They have been concerned, for example, with the growth and differentiation of individual nerve fibers and with the various factors that control and modify these processes. During the war Dr. Weiss was called upon by the Office of Scientific Research and Development to apply some of his principles and methods to problems concerned with nerve regeneration. The relation of this to war wounds involving the nervous system and to war surgery is obvious. Dr. Watterson works on the embryonic stages of chickens and is particularly concerned with an analysis of the development of blood vessels as the embryo matures. For example, he has traced in a meticulous way the origin of the pattern of blood supply surrounding the nerve cord.

The physiology of reproduction is being studied by Professor Carl R. Moore, Chairman of the Department of Zoology, and by his colleague, Dr. Dorothy Price, Assistant Professor of Zoology. They work with various sorts of mammals, primarily rats, guinea pigs, hamsters, and opossums. Many notable contributions about the action of sex hormones and other endocrines have emerged from Dr. Moore's laboratory. He has been a leading figure in showing that certain hormones produce certain effects on the reproductive system of both male and female mammals. Dr. Moore is also using the opossum for some very novel studies, attempting to analyze the role of hormones in certain phases of embryological development. The opossum is uniquely adapted to this study because the young are born in a very immature state, lying outside the body of the mother attached to a nipple, and thus can easily be experimented upon *in situ*. The young are embryos, to all intents and purposes. Last summer Dr. Moore and Dr. Price worked at three different altitudes in Colorado, attempting to analyze the relation between altitude and reproductive effectiveness, using rats as experimental animals.

Genetics is represented by Dr. Sewall Wright, Ernest D. Burton Distinguished Service Professor of Zoology and Associate Professor H. H. Strandskov. Dr. Wright is internationally known for his studies in population statistics and in physiological genetics. In the former field he has developed a coherent mathematical theory to deal with the distribution of genes in terms of evolutionary time and with the important categories of factors that affect this distribution. In the latter field he has

made significant contributions on the relation of the physiological action of genes in the formation of hair and color patterns in guinea pigs. Dr. Strandskov is an authority in the field of human genetics. His researches have been concerned primarily with human twins.

Ecology is represented by Professors W. C. Allee, A. E. Emerson, and Thomas Park. Dr. Allee has concerned himself primarily with the study of animal aggregations and the social order exhibited by various groups of animals. As a consequence of his many years of research, he has been led to the formulation of broad philosophical principles that afford support for the idea that there is an underlying cooperation exhibited by groups of organisms. It is usually assumed that animals are only competitive or antagonistic to one another. Professor Allee's researches have convinced him that this is by no means always true and that "unconscious cooperation" in biology is a principle of fundamental significance. Professor Emerson is one of the world's authorities on termites, and he has used these organisms in deriving broad biological principles about animal distribution and taxonomy. In addition, he has formulated a number of interesting generalizations about evolution and the formation of species. Dr. Park is analyzing, by laboratory methods, the quantitative nature of population competition between two species of organisms grown under carefully controlled conditions. In these studies he is using two small beetles, both of which inhabit flour and whose total environment can be precisely controlled.

Physiology. Dr. Ralph Gerard and his colleagues in the Department of Physiology worked for two decades on the chemical and electrical properties of nerve and brain. They are now engaged on a special research project to correlate these two aspects more closely, for the chemical changes supply the energy that enables the nervous system to function, and the electrial changes offer the most delicate measure of its functioning. There is reason to believe that the extra energy needed for activity, as compared to the resting condition, is obtained by nerve by burning phosphorus compounds of fat or protein. This is one problem that should be settled soon, especially with the aid of radioactive phosphorus. Much the same methods should reveal whether a phosphoprotein moves out along nerve fibers from the main part of the nerve cell, and how such movement is altered under various conditions. Further, by interfering with one or another step in the chemical sequences occurring in nerve or brain and noting the resultant disturbances in functioning, it should prove possible to identify the particularly important steps in normal function. This can be done by adding appropriate drugs or chemicals to isolated nervous tissue or by adding them to the blood to be carried to the nervous system still in the animal. From such studies will come ultimately an understanding of how the brain works normally and so of what the aberrations are in disease and how to correct them.

Obstetrics and gynecology. The Department of Obstetrics and Gynecology under the direction of Dr. Wm. J. Dieckmann, Chairman, has sponsored or aided in the development of the following:

1. Decreasing the number of babies that are born dead or die during the first month of life by emphasizing the importance of proper care during pregnancy and the omission of drugs during labor if the baby is born prematurely or by Caesarean section. Lowering the number of deaths of mothers by intelligent prenatal care and by repeated hospitalization whenever necessary. The use of glucose and saline solutions and of blood transfusions whenever indicated. All of these and the careful supervision and instruction of the resident staff has resulted in a maternal mortality of approximately less than 1 per 1,000.
2. Ergotrate, which is used to prevent bleeding after delivery.
3. Study of various analgesic and anesthetic drugs used in childbirth.

4. Clarification of the two general types of high blood pressure that may occur in pregnant patients.
5. The determination of standards for determining which pregnant patients are anemic.
6. Studies of the various agents used to cure various infections causing leucorrhea.

UNIVERSITY OF ILLINOIS

CHICAGO PROFESSIONAL COLLEGES

THE University's professional colleges of Medicine, Dentistry, and Pharmacy, and the 485-bed Research and Educational Hospital are located on a 12-acre campus. More than 1,250 students receive instruction each year from the staff of 900 faculty members. The Chicago plant of the University is valued at $10,000,000. The professional colleges and hospitals are headed by Dr. A. C. Ivy, who serves as Vice-president of the University.

The University's College of Medicine, staffed by 800 physicians, is the largest medical school in the nation from an enrollment standpoint. Half the student body on the Chicago campus of the University, or 630 students, is enrolled in the College of Medicine. The College has been operated by the University since 1913. Almost all members of the staff are actively engaged in research in addition to teaching.

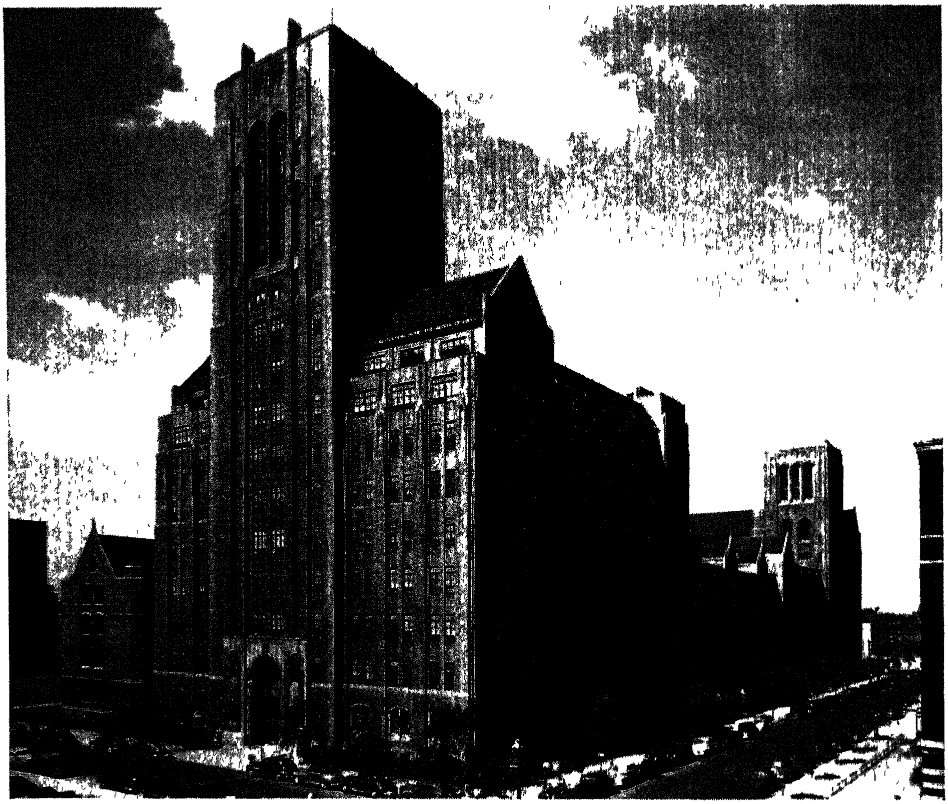
In a study on convalescence, Drs. Warren H. Cole and Robert W. Keeton have determined that it is possible to eliminate insufficiencies arising from operations by utilizing various forms of treatment. They are now conducting tests to determine the speed of convalescence. The Department of Surgery, headed by Dr. Cole, also has developed a new method of treatment for strictures of the common bile duct.

Dr. G. E. Wakerlin, head of the Department of Physiology, is currently conducting research on the prevention and treatment of experimental hypertension as a promising approach to the important problems of cardiovascular diseases.

Recently, the University contributed to public-health education by presenting "The Miracle of Growth," a dramatic exhibit of growth and development of the individual from conception through adulthood, to the Museum of Science and Industry [see page 461]. The display, conceived and created by the Department of Medical and Dental Illustration, utilizes a variety of exhibit techniques. It will be used by school children, by parents for the instruction of their children, and by the general adult public as an impersonal source of accurate information.

During the past year the Department of Pharmacology supervised all toxocological analyses for state's attorneys and coroners in the 52 counties of Illinois Research in pharmacology has included all types of blocking agents such as "benadryl," curare-like drugs, sympathicolytic drugs which may prevent high blood pressure, and new analgesic drugs more potent and less habit-forming than morphine or heroin.

The Illinois Neuropsychiatric Institute, headed by Dr. Francis J. Gerty, has studied such problems as glucose metabolism in acute psychoses, isolation of an anti-insulin factor in schizophrenia, and the use of carbon-dioxide inhalations in the treatment of several forms of mental disorder. Dr. Warren S. McCulloch has mapped out the functional relationships of the cortex and nuclei of the brain in areas in which such mapping had not been previously performed. A new electric stimulator, made by Craig Goodwin, has been used successfully in the work. Dr. Frederic A. Gibbs and Erna L. Gibbs have been engaged in intensive research on epilepsy, involving particularly the relationship of disturbance in the temporal cortex of the brain to psychomotor seizures. They also have conducted studies on blood passing to, and coming from, the brain, by means of a special technique involving direct approach to the blood supply of the internal carotid artery and



DENTISTRY, MEDICINE, AND PHARMACY BUILDING, UNIVERSITY OF ILLINOIS
THE CAMPUS OF THESE PROFESSIONAL COLLEGES IS LOCATED ON CHICAGO'S NEAR WEST SIDE.

internal jugular vein. Dr. Gibbs has made studies of the electrical activity of the deeper portions of the brain and has been active in promoting a program he established in Illinois two years ago for the prevention, diagnosis, and treatment of epilepsy.

The University's College of Pharmacy ranks as the only accredited school of pharmacy in the state. The fifty-one-year-old college has a staff of 36 full-time members to instruct its current registration of 430 students. Seventy percent of the state's pharmacists are graduates of the state university.

Another integral part of the Chicago campus of the University of Illinois is the College of Dentistry, with its 160 students and 40 faculty members. The University assumed control of the College in 1913.

In dental research Dr. Isaac Schour has studied the growth of teeth and the role of nutrition and the endocrine glands in tooth development. He laid the foundation of tooth-ring analysis as a biologic method of analyzing the health and nutritional status of the growing individual. Recently, he conducted clinical studies in Italy on the effects of malnutrition on caries and periodontal disease.

Dr. Stanley D. Tylman has gained recognition as the first to use plastics in the construction of artificial ears, noses, and fingers. He has been working with flexible plastics for six years and has returned many patients, including disfigured service-

men, to a normal appearance through the use of artificial restorations.

The University's program of providing facilities for teaching, research, and treatment in the health professions also includes plans for a college of nursing, under the direction of Mrs. Ann Lucille Laird, R.N.

At the present time, the University offers orthopedic, neuropsychiatric, and pediatric nursing courses for senior cadet and affiliate student nurses. Plans also have been formulated for a four-and-a-half-year course in nursing education.

The 485-bed Research and Educational Hospital operated by the University ranks among the nation's leaders in its field. A total of 140,000 outpatient visits are handled annually by the hospital's 24 clinics, and an additional 6,000 patients receive bed treatment each year.

The Hospital, operated and staffed by the University since 1926, has attained a high degree of selectivity in the admission of patients, based upon their teaching and research value. Hospital care and clinic treatment have been limited to residents of the state who are unable to pay for such services.

Through the leadership of Dr. Ivy, a large research program has been inaugurated with the proposed construction this fall of the Institution for Tuberculosis Research and the Aero Medical and Atmospheric Environment Institute.

The University has been designated by the U. S. Public Health Service as the sole facility in the nation for the manufacture of BCG (bacillus of Calmette and Guérin) vaccine. Wholesale processing of the preparation will be launched in a new tuberculosis research hospital costing $361,250. The University and the Chicago Municipal Sanitarium will work in close cooperation on the project. The vaccine, it is hoped, will extinguish the threat of tuberculosis in the U. S. within twenty to forty years. University scientists associated with the project are convinced that the need for sanitariums treating the disease can be eliminated within that time if BCG is administered to every child and adult not now infected with tuberculosis. Immunity conferred by the vaccine lasts from five to seven years. The preparation is taken from the same germ strain that was isolated from an infected cow by French scientists Calmette and Guérin in their original experiments in 1908.

The Aero Medical and Atmospheric Environment Institute will be erected and partially equipped at the cost of approximately $400,000. The laboratory, destined for the study of atmospheric effects on the body, will provide the University with a complete program in the fields of atmospheric environment and aviation medicine. The Institute is expected to give the University the most complete over-all aviation medicine program of any college in the nation and will provide the Air Force with trained personnel in the specialized field.

A prospective $13,000,000 building program comprises a research institute for chronic illness and geriatrics, a hospital for cancer research, an experimental research building, a drug-plant research station, a nurses' residence, student residence halls, a power plant, and a utilities distribution system.

The staff of the University's professional colleges does not confine its activity to Chicago alone. Hardly a day passes that one member or more of the staff does not speak to some group downstate. A large proportion of the patients in the hospitals, referred to the University by their own physicians, reside in downstate areas. At the present time the University is considering the extension of its pediatric service, its intern service, and its resident physician service to downstate residents. The University also is aiding in a plan to increase the number of physicians per capita in southern Illinois.

INSTITUTE FOR NUCLEAR STUDIES, THE UNIVERSITY OF CHICAGO

By SAMUEL K. ALLISON

Professor Allison (Ph D , Chicago, 1923) did research at Harvard and the Carnegie Institution before going to the Department of Physics, University of California A specialist in nuclear physics, he has been at The University of Chicago since 1930. Dr. Allison is Director of the Institute for Nuclear Studies.

DURING the recent war The University of Chicago administered and housed the Metallurgical Laboratory, acting at the request of the government. The Metallurgical Laboratory was part of the Metallurgical Project, whose task was the initiation of the uranium fission chain reaction and the development of methods for the production of plutonium in amounts of military significance. Almost the entire staff of the Physics and Chemistry departments of the University became associated, in part or in full time, with the work of the Project, and many persons from the Biological and Medical divisions added their contributions. The majority of the wartime staff, of course, was contributed by universities and industries widely scattered over the United States.

To satisfy the demands of military security in wartime, the name "Metallurgical" was chosen as a blind to cover the actual work underway, and, in fact, the original Project seemed to demand the services of a small group of experimental and theoretical physicists interested in nuclear physics. The term "Metallurgical" soon became less of a misnomer, however, and during one period it actually described the major part of the Laboratory's work. This misadventure in security indicates how the program broadened into the fields of chemistry, biology, medicine,' metallurgy, meteorology, and even into ichthyology.

As the collaborative effort surmounted obstacle after obstacle and it became clear that the Project would succeed, leading members of the University faculties and of its administrative staff became more and more enthusiastic about keeping together, in some more permanent form, groups of scientists interested in, and stimulated by, the great developments in nuclear physics and chemistry. In the fall of 1945 the University administration, with the approval of the Board of Trustees, announced the founding of three institutes as an outgrowth of this idea. They became known as the Institute for the Study of Metals, the Institute of Radiobiology and Biophysics, and the Institute for Nuclear Studies.

The program, in very broad outline, of the Institute for Nuclear Studies, is to conduct researches in nuclear physics, radiochemistry, and the chemistry of the separation of isotopes. In it an attempt is being made to attain the complete fusion of the sciences of physics and chemistry, at least in their advanced aspects. At the time of founding the Institute, it was not clear to what extent the program could involve direct contributions to the development of atomic power as a peacetime project. Some members thought that such a scientific-industrial program might be the core of the Institute's activities. However, it has become the policy of the nation, as expressed in the atomic-energy legislation passed by Congress, not to make public nor share with other countries the methods and processes of the application of atomic power during the present fretful state of the world. This policy made it impossible for the Institute, as a part of the University, to participate

directly in such an effort. Several Institute members, in their capacity as consultants to the laboratories of the Atomic Energy Commission, frequently visit these institutions and lend such aid as they can to the industrial and military projects being undertaken there.

In the organization of The University of Chicago, the Institute for Nuclear Studies and the Institute for the Study of Metals are parts of the Division of the Physical Sciences, which includes the departments of Astronomy, Chemistry, Geography, Geology, Mathematics, Meteorology, and Physics. The administrative officer most closely associated with it is, therefore, the Dean of the Physical Sciences.

Academic appointments as professors of various ranks on the staff of the Institute for Nuclear Studies are in no way different from appointments in the traditional departments. The Institutes, however, can make technological appointments of a type not found in the departments; thus, appointments such as Electrical Engineer in the Institute for Nuclear Studies can be made. Some of the Institute members have accepted appointments in the departments of Physics or Chemistry, thus becoming joint appointees of a department and the Institute; others have preferred to remain Institute members only.

The Institute is not a degree-conferring branch of the University; its major interest is in research at the postdoctorate level. With the understanding and approval of the department concerned, however, candidates for advanced degrees in the departments may prepare their theses under the supervision of Institute members. The thesis so prepared must, of course, meet the requirements of the department for the degree being sought.

Some of the research activities of the Institute, as described below, are supported by the Office of Naval Research of the United States Navy. Contributions to the operating expenses have also been made by the Standard Oil Company (Indiana), the Standard Oil Development Company (New Jersey), the Shell Development Company, and the Sun Oil Company. The major part of the budget is being supported by the University at the present time.

It may be appropriate to describe the Institutes as stepchildren of the Metallurgical Project, and the Argonne National Laboratory as one of its direct lineal descendants. At the request of the Atomic Energy Commission, the University is continuing to administer the Argonne National Laboratory, although its program and policies are controlled by a council chosen from a large number of Midwestern universities. In a formal sense, a member of the Institute has the same status with respect to the Argonne National Laboratory as does any scientist in the group of universities that determines its policies; namely, by mutual agreement with the Laboratory, he can carry on researches there using the chain reactors or other equipment the Laboratory can assign to his research problem. Actually, of course, owing to the propinquity of the two institutions and the fact that many of the members of both worked together on the parent war project, it has been especially easy for the Institute members to avail themselves of the privileges extended by the Argonne Laboratory.

The Institute, up to the present time, has been greatly embarrassed because of lack of space and, to a lesser extent, of equipment with which to carry out its experimental work. During this period it has been very fortunate to have had access, for several of its members, to the Argonne facilities.

The Institute, on the physics side, will, in large part, be occupied with a study of the properties of high-energy particles consisting of beta rays and photons from a 100,000,000-volt betatron, and accelerated atomic nuclei from a 350–400,000,000-volt

synchrocyclotron. Since these machines are made to produce very high-energy particles in narrow beams of high flux per unit cross section, they cannot compete with the chain reactor in the production of total fluxes of neutrons of thermal and intermediate energies. For experiments requiring the latter, the Institute will continue to request the privileges of the Argonne Laboratory

THERE has been no attempt to organize extensive research programs within the Institute. Each member has been free to follow what seem to him interesting and promising investigations. Certain projects, such as the restoration of the Chicago cyclotron, and the development and design of the new 170-inch synchrocyclotron, have, in their very nature, required the organization of groups for carrying them out.

The restoration and improvement of the Chicago cyclotron, which was constructed in the period 1935–37 by Professor W. D. Harkins, with the assistance of Drs. R. J. Moon, H. W. Newson, A. H. Snell, and L. A. Slotin, have been prominent in the activities of the Institute. The work has been sponsored by the Office of Naval Research, under Contract ONR–21, Task Order III, and has been directed by Dr. G. Groetzinger. The technique of health protection from exposure to penetrating radiation was greatly improved during the war through the activities of the atomic-bomb project, and protection that had previously seemed adequate failed to conform to the new standards. It was necessary to discard the old water-tank shielding and replace it with 3 feet of concrete in the form of blocks that could be handled with an overhead crane. Many of the auxiliary parts of the original cyclotron had become obsolete, and replacement was necessary. The rebuilt cyclotron was put into operation during March 1947. It produces a beam of 7.5 Mev deuterons, with currents on the order of 100 microamperes. Its reliability and steadiness in operation are continually being improved.

Another Institute activity has been connected with the important radioisotope carbon 14. This long-lived radioactive form of carbon is now being artificially produced from nitrogen in the chain reactors at Oak Ridge, Tenn., and can be purchased from the Atomic Energy Commission by properly qualified scientists. Under Professor W. F. Libby, a group of Institute scientists began to look for this radiocarbon in nature, taking a hint from its artificial method of manufacture according to the reaction

$$_{7}N^{14} + _{0}n^{1} = _{6}C^{14} + _{1}H^{1} + 0.54 \text{ Mev.}$$

Physicists studying cosmic radiation have discovered the presence of a neutron component in our atmosphere. These neutrons become slowed down by repeated impact with the nuclei of the atoms of the gases of the atmosphere and eventually reach energies comparable with the kinetic energies of atoms and molecules at the temperatures of the lower part of the atmosphere. The nitrogen nuclei in the air have a greater avidity for absorbing these neutrons than do the other common constituents of the air, and thus most of the neutrons are converted into carbon 14. The newly born carbon atom, either by direct interaction with atmospheric oxygen or through intermediate compounds, forms carbon dioxide.

Since the radioactive half life of this carbon 14 is about 3,000 years, the average atom lives this long until it dissociates into nitrogen 14 and an electron:

$$_{6}C^{14} \rightarrow _{7}N^{14} + e^{-} + 0.20 \text{ Mev.}$$

The carbon 14 produced has accumulated or decayed in various parts of the earth until an equilibrium state has been attained practically everywhere in which as many carbon atoms decay in a certain time interval as appear, owing to their direct production, or diffusion, or transport to that region by convection or other means.

The carbon dioxide in our atmosphere is absorbed by the plant life on the surface of the earth or, as CO_2 dissolved in the oceans, is fixed by the life in them. Animals and men eat the plants, or eat other animals that have eaten plants, and thus the carbon 14 becomes part of our bodies and of all living things. A constant interchange with the atmospheric carbon dioxide goes on; through the deaths of animals and plants, through forest fires, and countless other processes, carbon dioxide, which was once a part of living things, returns to the atmosphere.

A corollary of the preceding discussion is that carboniferous material that has long been out of participation in the exchange between plants, animals, and the atmosphere should not contain the radioactive form, whose average life of 3,000 years is minute compared to the epochs of time in the geologic ages. Thus, carbon in petroleum or coal deposits that have been buried for untold millions of years should not be radioactive, and natural gas from deep wells, mostly consisting of methane, should consist of inert carbon.

Professor Libby obtained some mineral, or petromethane, and compared it with biomethane obtained from biological wastes in the sewage from the city of Baltimore. In order to make the test for radioactivity more sensitive, the two methanes were put through an isotope separation that concentrated the heavy carbon isotopes (carbons 13 and 14, if any) at the expense of the predominant carbon 12. The extent of the concentration could be measured by keeping track of the enrichment of carbon 13. As the enrichment of biomethane progressed, a steadily increasing radioactivity was noted, whereas with petromethane no activity above background level could be found. This interesting result gives a method of distinguishing mineral methane from methane generated in surface swamps from the decay of vegetable matter, and from biomethane in general. The thought that the carbon in an Egyptian mummy should contain less radioactivity per gram than that of tissue from a recently living animal has lead to speculation about the possibility of dating such remains from their specific activity. Frozen mammoth flesh from the finds in Siberia should indicate, by its low activity, how long ago the beast stopped participating in the carbon-dioxide cycle.

Another Institute activity, sponsored by Professor E. Teller, has been the investigation of the adequacy of the drop model of the nucleus to explain the observed fact of asymmetric fission. When a heavy nucleus of uranium, thorium, or plutonium breaks into two roughly equal parts in the process we call fission, just what parts, called fission products, will result from a given nucleus about to split cannot be foretold. If, however, we have a very large number of nuclei about to split, the fraction of this number that will split into a given set of products can be closely estimated from experiments previously carried out. Curiously enough, the symmetric mode of fission, in which the two fission-product nuclei have equal masses, is practically absent. It is very much more probable that fission products of unequal masses will result. Why this asymmetry?

It has been proposed that we try to see how many of the properties of a heavy nucleus we can predict through the type of calculation applicable to a liquid drop. The nucleons, that is, the neutrons and protons, may act somewhat like the molecules of liquid, and the mysterious forces between nucleons may have some analogue in the intermolecular forces. A kind of surface tension skin would enclose the nucleus. If such a drop nucleus is thrown into agitation by giving it excess energy, can we explain why it should split asymmetrically? A pertinent feature may be that the charged nucleons, the protons, which are concentrated

in the periphery of a spherical drop due to their mutual repulsion, would, in any perturbation of the spherical shape, run to that portion of the structure in which they could be most widely separated from each other.

The problem of calculating the result of a perturbation in the spherical shape is an extremely complex and tedious one, and was carried out by Professors Frankel and Metropolis with the aid of the ENIAC electronic computing machine built during the war for Aberdeen Proving Ground. The results indicate that the drop model, as we know it today, is inadequate to explain the observed phenomena of asymmetric fission, and that a new model, or an elaboration of the present one, will be necessary.

The Institute is also engaged in researches directed by Professor Urey on the isotopic composition of oxygen in living matter, or in the products of living matter. Normal oxygen, as in our atmosphere, is composed mostly of oxygen 16, with minute but definite amounts of oxygens 17 and 18. The theory of the fixation of oxygen by living matter in the oceans into calcium carbonate, forming the hard protective or structural constituents of many sea animals and plants, indicates that a slight variation in the composition of the oxygen is to be expected, and that this change is temperature-sensitive, so that an isotopic analysis of a shell might reveal whether the animal had lived in the warm equatorial surface waters or in the cold polar seas.

Drs. Fermi and Teller have made a theoretical investigation into the nuclear capture of negative mesons traversing matter. Since atomic nuclei have a positive charge, a negative meson is attracted and quickly bound in a quantum state, in which, for a certain fraction of the time, it moves close enough to the nucleus to be within the range of nuclear forces. According to their calculations, it should be trapped in the nucleus in a time interval very small compared to its natural radioactive mean life, about 1.6 microseconds. This behavior is quite different from that of a positive meson, which is not captured in a nucleus, but, after being slowed down by imparting energy to the electrons of the stopping material, dies a natural death after a few microseconds.

Experiments have shown, however, that disintegration particles, emitted on the order of microseconds after the stopping of the meson, are actually observed for negatives, which, according to the above argument, should have been murdered long before they could die a natural death. The discrepancy cannot be explained by any of the present meson theories, and an important revision of them, or their abandonment, seems called for.

Without attempting to list the entire gamut of Institute researches, the roster of which changes week by week, we may call attention to:

A study of the mechanism of the quenching action of organic vapors in Geiger-counter tubes.

Application of electron-multiplier tubes to nuclear research, including a search for the neutrino through the measurement of the recoil of a nucleus after beta-ray emission.

Development of a new method of mineral analysis based on radiochemistry, and application of it to a study of the composition of meteorites (the beginning of cosmic chemistry).

Attempts to verify the existence of, and to identify, if found, the positive particles that have been reported in connection with emission of negative electrons from radioactive nuclei.

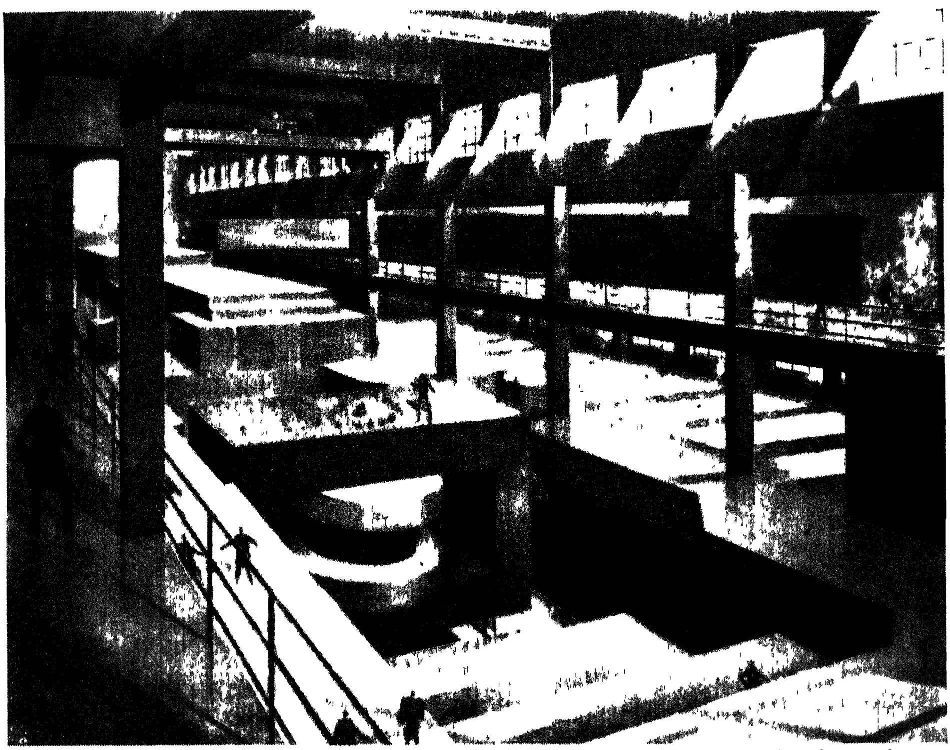
A search for emitters of alpha particles among naturally occurring "stable" nuclei.

Studies of the rarer fission products and of the chemical nature of delayed neutron emitters in fission.

Investigations of chemical reactions that follow a radioactive transformation of one of the atoms in a molecule.

A study of the magnetic susceptibilities of the ions of the salts of the heaviest elements, in aqueous solution.

A search for a possible excited state of the nucleus beryllium 7, and an attempt to measure the negative energy of binding of beryllium 8.



Schmidt, Garden & Erikson, Architects, E. B. Jackson, Consulting Architect

THE INTERIOR OF THE ACCELERATOR BUILDING

Some of the above problems may yield interesting results in a relatively short time. Others may be dropped because of technical difficulties or waning interest. Still others may be the beginning of a research program of many years' duration.

It is inconvenient to accommodate a modern program of radiochemical research in the conventional chemical laboratory, and almost impossible to use the standard physics laboratory for present-day nuclear physics. Radiochemistry needs air-conditioned counting rooms for assays of radioactivity, laboratories where remote-control operations can be carried out with the operators protected behind radiation shields, and special facilities for disposal of radioactive wastes.

The majority of the fundamental researches in nuclear physics during the next decade will probably be made with the aid of beams of very high-energy particles. Modern ion accelerators are extremely large machines with complicated electric circuits and controls. The radiation level around these machines is so high that they must be placed in concrete pens with walls as much as 8 feet thick, and the various parts of the machines have become so heavy that they must be manipulated with cranes. Such installations cannot, as a rule, be housed in ordinary university buildings.

The buildings that will be the future home of the Institute for Nuclear Studies are to be constructed as a part of the campus of the University in the block between Fifty-sixth and Fifty-seventh streets and Ellis and Ingleside avenues. The main building, consisting of laboratories and offices, will be a wing of a much larger structure that will also house the Institute for the

Study of Metals and the Institute for Radiobiology and Biophysics. The large ion accelerators will be housed in the Accelerator Building, which will be connected to, but structurally independent of, the main buildings.

The Accelerator Building is planned to house a 100,000,000-volt research betatron, a 170-inch synchrocyclotron, and the present Chicago cyclotron, probably with a new accelerating chamber permitting orbits approximately 40 inches in diameter. The building will be essentially a housing for a traveling crane, with working space beneath the crane where heavy machinery and concrete shielding blocks can be placed. The crane will have a lifting capacity of 70 tons on 2 hooks. It will have a span of about 50 feet and a run of approximately 200 feet. The accompanying drawing shows a view of the interior of the building as seen by an observer in the northeast corner of the second floor, looking down into the main part of the building through the opening in which the crane will operate. The 170-inch cyclotron is shown in its pit, which places the bottom of the magnet yoke 20 feet below the floor level of the basement, or working, floor of the building, which itself is 7 feet below ground. The pit will eventually be covered with slabs of reinforced concrete of a thickness sufficient to lower the radiation level outside to a value where it will not interfere with other experiments. Access to the pit will be provided through an elevator shaft near its northeast corner, which will communicate with the lower level of the pit through a horizontal tunnel. There will also be an entrance in the east wall directly opposite the vertical member of the magnet yoke. The control room will be located on the working floor to the east of the pit and will communicate with the pit through a winding stairway leading down to the entrance near the magnet yoke.

A concrete ledge overhangs the pit on its west, north, and east walls. Thus, when the roof beams are laid on to the full width of the bottom of the pit, this ledge will complete the radiation seal around the upper edges of the opening.

A trucking entrance from Ellis Avenue is provided for in the northeast corner of the building so that shipments of heavy units can be brought in under the crane and then lifted and transported easily to various parts of the building.

Ground was broken for the Accelerator Building on July 8, 1947. The plans for the main laboratory, which is to extend to the south of the Accelerator Building, are being detailed, and construction is expected to begin early in 1948. As the new construction begins to relieve the shortage of space, and the high-energy machines come into operation, the Institute, which is now dispersed in temporary quarters, will begin a new and better-integrated phase of its existence.

INSTITUTE FOR THE STUDY OF METALS, THE UNIVERSITY OF CHICAGO

By CYRIL STANLEY SMITH

Dr Smith (Sc.D., M I.T., 1926) came to this country from his native England after receiving his B.Sc. at Birmingham In 1927 he became a research metallurgist for the American Brass Company, Waterbury, Conn., where he remained until World War II took him into special war research. He is Director of the Institute for the Study of Metals.

THE advancement of engineering science, and consequently the enhancement of the economic well-being of society, is dependent to a large extent upon the development of new, and the improvement of old, materials. Certain materials, such as plastics, have undergone spectacular improvements in recent years. On the other hand, the metal industry has little reason to be proud of its recent over-all record in producing new and better metals. A marked advance has taken place only in very specialized fields—such as ferromagnetics—fields in which intensive research will bring immediate and foreseeable profits to the sponsoring organization. More efficient power generation is dependent largely upon the development of metals that will retain their strength at higher temperatures. The introduction of lighter transport vehicles is conditioned upon enhancement of the ability of metals to withstand repeated loading, technically known as their fatigue resistance. The introduction of the lighter metals, such as magnesium, beryllium, and aluminum, can proceed only as rapidly as we are able to increase their power of resisting attack by the chemicals ever-present in the atmosphere, technically known as their corrosion resistance. These problems, as well as many others related to the performance of metal products, are being actively investigated by large groups of research workers. The lack of marked progress does not, therefore, lie in a lack of intensive effort. Rather, it lies in the almost complete absence of a science of metallurgy, a science which should be guiding the numerous research programs, and without which the programs must proceed by the laborious and costly trial-and-error method.

Several interacting factors have contributed to the retardation of the development of a science of metallurgy. Metallurgical research, and instruction in metallurgy, are expensive. As a consequence, only a few universities have departments of metallurgy, and the number of Ph.D.'s trained annually in metallurgy is very small compared with the number trained in physics or in chemistry. The majority of these metallurgists are attracted to industry. Those few that remain in universities are confronted with almost irresistible temptations to serve as consultants to industry, and their interests and energies are thereby directed away from the development of metallurgy as a science. Perhaps because of this close connection of metallurgists with industry, physicists and chemists have regarded metallurgy as an engineering subject rather than as a science, or even as a potential science. When physicists deem certain subjects in metallurgy worthy of consideration, they label these "the physics of metals"! This aloofness of physicists and chemists has acted as a barrier to their even becoming acquainted with those problems in metallurgy that would excite their scientific curiosity.

The Institute for the Study of Metals at The University of Chicago has been formed for the express purpose of developing the science of metallurgy. Attempts are being made to avoid those obstacles that in the past have retarded this development. The

members of the Institute, like most other members of the University, are under contract to receive no outside earned income. The members have, therefore, no distractions other than those arising from their own scientific curiosity. The Institute contains approximately equal numbers of metallurgists, physicists, and chemists. The mere act of bringing these three groups physically close together has engendered in each group a high esteem for the others, an esteem necessary for any true collaborative research. The personnel of the Institute numbers about sixty, of whom about a third are academic.

Since the Institute has been formed for the purpose of developing the science of metallurgy, it will not be engaged in the development of particular metals for particular purposes. Such development is regarded as belonging more appropriately to the research laboratories of the various metallurgical industries. The Institute can therefore be regarded in no manner as being in competition with these industrial research laboratories. Rather, it is intended that the results achieved by this Institute will be used by the various industries as a guide in their development of special-purpose metals. Conversely, it is anticipated that the resulting cordial relations existing between the members of the Institute and the members of industrial laboratories, and the consequent exchange of experiences, will be of substantial aid to the former in their development of a metallurgical science.

It is hoped that the Institute will be joined in its objectives by groups and isolated individuals in other universities. To further this end, the Institute invites lecturers from other universities and provides facilities for metallurgists, physicists, and chemists who might wish a leave of absence from their universities in order to work for a year within the Institute.

The Institute forms an integral part of the University, being administratively on a par with other departments within the Division of Physical Sciences. Unlike a department, however, it has no instructional responsibilities and hence does not grant degrees. Invitations may, however, be extended to its members to become members of one of the departments and thereby to assume teaching responsibilities. Thus, several members of the Institute have joined the departments of Physics and of Chemistry. Through such associations the science students become familiar with the research activities within the Institute. Because of these joint memberships, students of physics or of chemistry may do their Ph.D.-thesis work within this Institute under the guidance of one of its members.

As in a department, lines of authority among the staff members exist only in budgetary matters. Any joint research is purely on a voluntary basis. Nevertheless, each permanent member is expected to do some service work for the other members. Thus, the metallurgical group prepares specimens, the chemistry group gives analyses, and the physics group develops special instruments. Only by means of this mutual service can the individual members pursue research programs that require the combined talents of the three types of scientists. In order partially to relieve the burden of this service work, the Institute also makes professional appointments, such as professional metallurgist, etc.

In most departments it is customary for professors to seek aid from graduate students working toward degrees. The necessity of such a professor-student relationship is unfortunate. The professor gets less actual help than he would from paid assistants who remained with him over a period of years. On the other hand, the student gets so much help in his "research" that he gains no appreciation of the value of the initial planning of a program. In the Institute each research member receives as much aid as he desires in the form of

technical assistants. On the other hand, those students working in the Institute for higher degrees are under no compulsion to work upon a problem that forms part of a more general program of a staff member.

Postdoctorate fellowships are available for students from other universities who have had their training in physics, chemistry, or metallurgy. The primary purpose of these fellowships is to provide men who have already acquired a sound scientific training with an acquaintance of metallurgical problems and techniques. It is anticipated that they will form centers of metallurgical research in the universities to which they will later go.

In order that the science of metallurgy may be based upon as broad a foundation as possible, the Institute is being equipped, and specialists have been assembled, to study metals under a wide range of conditions. For studies at low temperatures a cryogenic laboratory is being built, and cryogenists have been brought from Berkeley and from Leiden. Standard equipment has been installed for studies at the highest attainable temperatures. A special laboratory is being built for studies at high pressures. The metallurgists have furnaces which turn out single crystals with the greatest ease and which, on the other hand, can prepare specimens of any grain size down to the smallest yet produced. One of the most complete X-ray laboratories has been assembled by this country's leading crystallographer. The chemical analysis group is equipped and trained for all methods of analysis—straight chemical, spectrochemical, etc. The physics rooms would remind one of an electronics laboratory if it were not for the large number of special-purpose furnaces.

It is just over two years ago that this Institute was first established. Although a considerable part of the energies of the staff has gone into routine matters of organizing laboratories, considerable progress has already been made in understanding the basic phenomena in metals, as is evidenced by the steady stream of publications from this Institute that are appearing in the scientific journals.

One inquiry being actively pursued is the search for the general laws governing grain growth. Within each grain the atoms are arranged regularly on lattice points. The orientation of the lattice planes differs, however, from grain to grain. When a specimen is heated, some grains grow in size at the expense of neighboring grains. Laws governing such growth in metals may be very similar to the laws governing the growth of foam cells.

Another program has as its objective an understanding of the mechanical properties of metals. How little is at present known may be realized from the fact that the specialists are not in agreement as to whether a perfect crystal would be very weak or very strong. The complexity of the problem may be comprehended from the fact that the strengths of some crystals may be doubled by the addition of only 0.01 percent of an alloying element, whereas that of other specimens may be greatly weakened by much smaller additions; and from the fact that specimens of the same chemical composition may have radically different mechanical properties, the specimens differing only in the mode of distribution of the different types of elements. Considerable progress has been made in differentiating the contributions to the mechanical behavior from the interior of grains and that made from the grain boundaries.

Another program relates to the thermodynamics and kinetics of the interaction of the constituent atoms in a metal. The chemistry of a solid has much in common with the chemistry of a living organism. In each, equilibrium is never attained; in each, the properties depend to a marked degree upon small traces of one constituent that

may segregate along interfaces. As an example, the addition of less than 1 percent of molybdenum to steel decreases by a factor of more than ten the rate at which carbides are precipitated during the quenching operation.

The atoms of common metals may be arranged in a lattice network of one of three types, known as body-centered cubic, face-centered cubic, and hexagonal close-pocketed. It is not known just what all the factors are that determine the particular lattice of a given metal. From a study of the differences in the vibrations of the first two types of lattice, it was suspected that lithium might undergo a slow change from one lattice type to another at low temperatures. This transformation was then looked for and found.

One of the difficulties of working at very low temperatures, say, less than 1° absolute, lies in methods of measuring how far one is from the absolute zero. A new method is being investigated in which direct use is made of the randomness of heat motion itself.

In keeping with the purpose for which the Institute for the Study of Metals was founded, it does not accept contracts to work upon special developments. Currently, a substantial part of its budget is financed by the Navy for the study of the laws governing the deformation of metals, and for a study of metals under high pressure. Several private companies have pledged substantial contributions over a period of five years, the only direct benefit they hope to receive being their freedom in discussing problems with the various members of the Institute It is anticipated that as the work of the Institute progresses in developing the science of metallurgy, the value of such a science to industry will be so self-evident that financial support will be more widespread. Conversely, the members of the Institute recognize the nearly ideal conditions under which they work, and hence feel it their responsibility to demonstrate to the world, through their work, the wisdom of an organization in which research is carried out unfettered by controls arising from lines of authority, or by restrictions arising out of special contracts for particular work.

LEGENDS REVERSED

In making up the article "Hitching our Country to the Stars," November 1947, the Editor of the SM inadvertently switched legends of two illustrations. The instrument shown on page 373 is Hassler's 24-inch theodolite; that at the bottom of page 375 is a zenith telescope.

INSTITUTE OF RADIOBIOLOGY AND BIOPHYSICS, THE UNIVERSITY OF CHICAGO

By RAYMOND E. ZIRKLE

Dr. Zirkle (Ph D , Missouri, 1932) is Director of the Institute of Radiobiology and Biophysics, to which post he went after a number of years as Professor of Botany at Indiana University. His chief interest is in the biological effects of neutrons, X-rays, and alpha rays.

THE INSTITUTE OF RADIOBIOLOGY AND BIOPHYSICS was created by The University of Chicago on October 1, 1945. The immediate object of its founding, like that of the slightly older Institutes for Nuclear Studies and for the Study of Metals, was to provide a continuity for basic research, need for which, in certain fields, had become painfully apparent during the prosecution of the wartime research and development projects, notably the ones dealing with nuclear energy. The Institute has been organized as an integral part of the University's Division of Biological Sciences (which includes the School of Medicine); its Director reports directly to the Dean of that Division.

The primary function of the Institute is research in the fields designated in its title. For the purposes of this discussion, radiobiology is defined as the study of biological effects of radiations—notably the high-energy, ionizing radiations such as X-rays and fast neutrons—and biophysics is defined as the study of the physical structure and functions of biological objects—a very broad field which probably cannot be fully covered by an organization of wieldy size. In addition to the primary function of research, the Institute takes part to a certain extent in instruction, cooperates with other members of the faculty in various research activities, and devotes a substantial fraction of its manpower and facilities to providing technical services to faculty members outside the Institute.

The staff consists of individuals trained in diverse fields of the biological and physical sciences. This diversity makes it possible for the members to form suitable teams for attack on specific problems. Sometimes the teams include members from other University organizations. The staff includes not only faculty members, but nonacademic persons of professional grade

Some research activities are not yet in progress because Professors Brues, Rose, and Shonka are currently on leave of absence to Argonne National Laboratory. The programs underway are mainly:

Biophysics of nerve (Cole, Marmont, Ferreira), with special reference to the electrical properties of the nerve impulse.
Studies on metabolic processes (Bloch, Abrams), emphasizing syntheses and featuring isotope-tracer techniques.
Studies on biological effects of radiations (Zirkle, Bloom, Boche, Ting), with chief emphasis on the mechanisms of various biological actions.
The physics of macromolecules (Szilard, Novick), specifically the nature of induced mutations in microorganisms.
Studies on localization of radioisotopes in normal and neoplastic tissues (Moon, Szilard, and members of the School of Medicine).
Mathematical analyses of experimental data and of experimental planning (Savage).

The Institute is temporarily housed in two buildings; the headquarters and part of the laboratories are at 6200 Drexel Avenue, and the remainder of the laboratories are at 6125 University Avenue. Each of these sites is about three-quarters of a mile from the middle of the campus; communications are maintained by automobile. The Institute is ultimately to share new buildings with the Institute for Nuclear Studies and the Institute for the Study of Metals. These buildings are to be on the campus in the

block bounded by Fifty-sixth and Fifty-seventh streets and Ellis and Ingleside avenues. The Accelerator Building is now under construction, and the remainder are in the blueprint stage [see page 487].

Major equipment now on hand includes extensive electronic implementation, especially for the work in nerve biophysics; numerous counters and accessories for assay of radioisotopes; two 250-kilovolt X-ray outfits, one designed primarily for irradiation of biological objects, the other for physical measurements and calibrations. A mass spectrometer for work with stable isotopes is under construction. The present University cyclotron, which produces 8 Mev deuterons, is available to Institute members for fast neutron irradiations and production of certain radioisotopes. Various other sources of radiations are available nearby in Argonne National Laboratory. When their construction is completed, the large betatron and the synchrocyclotron will furnish very high-energy X-rays, electrons, neutrons, and light atomic nuclei, all of which are of great radiobiological interest.

The Institute has an electronics development laboratory (Norris), a drafting and design group (Cross, Packard, Soderquist), and a well-equipped convenience shop staffed by two full-time machinists. Large jobs of equipment construction are carried out in the University's Central Shops, under the supervision of Mr. T. J. O'Donnell. Glass work is done in the Central Glass Shop in charge of Mr. C. C. Van Hespen.

The Institute, being a research organization, does not recommend students for degrees or provide curricula leading to degrees. However, a curriculum leading to the Ph.D. in biophysics has been set up in the Division of Biological Sciences under the administration of a Committee on Instruction in Biophysics. This Committee is composed of members of the faculties of the Division of Physical Sciences and the Division of Biological Sciences. The curriculum includes basic and advanced studies in both the physical and biological sciences and research for the Ph.D. dissertation. Each student's research is done under the supervision of any suitable faculty member, who, if not a member of the Committee, works with it in supervising the student's progress.

Because of its facilities and the emphasis on research, the Institute offers a favorable environment for postdoctoral training. It also offers formal courses in certain of its specialties that are not covered by the offerings of the regular teaching departments. For instance, the Institute is currently sponsoring, and furnishing a large share of the teaching staff for, a six months', full-time curriculum in radiation hazards, which is especially designed for medical officers in various government services.

OTIS WILLIAM CALDWELL, 1869–1947

By FRANCIS D. CURTIS

School of Education, University of Michigan

OTIS WILLIAM CALDWELL was born on December 18, 1869, in Lebanon, Ind. His parents were Theodore Robert and Belle C. Caldwell, prosperous farmers near Lebanon. His early years were spent on his parents' farm, where he received the upbringing and schooling typical of the country boy of his time. In 1894 he was graduated from Franklin (Ind.) College with the B.S. degree; four years later he received the Ph.D. in botany from The University of Chicago.

Dr. Caldwell's career as a college teacher began in 1899 when he accepted a professorship of botany in Eastern Illinois State Normal School. His activity in research, publication, and in the work of many scientific organizations soon brought him to the attention of other institutions of learning, with the result that in 1907 he accepted an invitation to join the staff of The University of Chicago. From 1913 to 1917 he was Professor of Botany and Dean of the University College. During this early period Dr. Caldwell gave his major attention to teaching and research in botany, earning for himself a permanent place among the country's outstanding botanists. In 1917, in recognition of the commanding position he had attained among scientists, his alma mater conferred upon him an honorary LL.D.

Although primarily a scientist, Dr. Caldwell excelled also as an educator. His great interest in classroom teaching and the training of teachers led him, in 1917, to resign his position at Chicago in order to accept a professorship in Columbia University, where he was to institute and administer the Lincoln Experimental School. He held this position until 1927. To the arduous duties of this important post he added those of administering the Division of School Experimentation. When, in 1933, he retired from the Columbia staff, he became Emeritus Professor of Education.

Dr. Caldwell's teaching was by no means limited to the institutions where he held regular appointments. In 1904 he taught in the University of Indiana Summer School of Biology; in the summer of 1931 he was a Visiting Professor at the University of California. Here he added substantially to his already great reputation as a distinguished lecturer by presenting a series of lectures on scientific subjects as a special feature of the summer session. He spent the year 1937–38 at Atlanta University, where he devoted his attention to the successful establishment of graduate work in education.

Dr. Caldwell was a prodigious worker. The huge quantity of his literary output is explained by the simple statement he once made to a close friend: "Hard work is no hardship. I *like* to work!" Few authors can approach in number and in variety of subject matter the list of books of which he was either sole or collaborating author. He published the first of a series of botanical textbooks and manuals in 1901. The last of these, *Introduction to Botany*, published in 1914, after many mutually pleasant and profitable years of authorship association with Professor J. Y. Bergen, is still a standard textbook in elementary plant study. Caldwell and Eikenberry's *Elements of General Science*, with its revisions, probably exerted a stronger influence in molding the subsequent development of general science than any other factor. In 1923, when textbooks of science written especially for junior-high-school students were practically unknown, Dr. Caldwell wrote *Open Doors to*

P. Stephens, Inc.

OTIS WILLIAM CALDWELL, 1869–1947

FROM 1913 TO 1917 HE WAS PROFESSOR OF BOTANY AND DEAN OF CHICAGO'S UNIVERSITY COLLEGE.

Science for them. Subsequently, he prepared a highly successful series of textbooks in general science and biology for secondary schools. His great versatility is evidenced by his publication (either alone or in collaboration with others), during his amazingly prolific years, of *Biological Foundations of Education*, a book of outstanding value to all teachers of biology and education; *Then and Now in Education*, a comparison of important educational trends and movements; *Do You Believe It?* a popular study of unfounded beliefs; and *Science Remaking the World*, a presentation of milestones of scientific research. Hundreds of his articles appeared in scientific and educational journals.

Because of his stature as a leader in the teaching of science, Dr. Caldwell served on many important committees. Prominent among them were the A.A.A.S. Committee on the Place of Science in Education, of which he was Chairman from 1924 until his death; and the Forty-sixth Yearbook Committee of the National Society for the Study of Education. In the recent report of that committee he was an active collaborator and the author of the only signed chapter, the final one: A Look Ahead: Science Education Imperative.

The great regard in which leaders in the fields of science and education held the scholarship of Dr. Caldwell is abundantly shown by his membership in Sigma Xi; his Fellowship in, and General Secretaryship of,

the American Association for the Advancement of Science, which latter position he held from 1933 until his death; his "starred" rating in *American Men of Science;* and his memberships in various educational societies. After his death on July 5 a prominent journal stated: "The death of Dr. Otis W. Caldwell . . . has ended a notable career in science and education." A distinguished educator and former colleague of Dr. Caldwell paid him this tribute: "The passing of this man marks the end of an era in science education."

But it was his other, more human qualities—his friendliness and his cordial interest in those with whom he came in contact—that, combined with his capacity for scholarship, made him a great leader. One of his associates of nearly fifty years ago designates him as "a delightful and genial companion and true friend . . . most successful and stimulating teacher, greatly beloved and respected by his students." At every educational gathering he attended he was sought out by crowds of friends, former colleagues, and students, eager to exchange greetings with him. He was esteemed, too, by his townspeople, few of whom realized the eminence of this modest and unassuming man, but many of whom loved him as a friend.

Dr. Caldwell was professionally active almost to the day of his death. Until nearly the end his plans were buoyantly for the future. His passing is an irreparable loss.

THREE QUESTIONS

"Is truth ever barren? . . . Will it not raise man's mind above the confusion of things? Shall he be able thereby to produce worthy effects and to endow his life with infinite commodities?"—Francis Bacon, 1561–1626.

Three hundred years and more have come and gone
Since Bacon's busy pen and curious mind
These questions to the centuries consigned;
How reads our answer, if there should be one?
Truth is not barren, benefits have flowed,
At first a trickle, then a torrent broad
From springs and wells of science; all applaud
Her gifts and gains, so lavishly bestowed.

But is man's mind above confusion raised?
How stands the audit of his aims and life?
Worthy effects are by but few appraised.
The many listen to the siren's song
Of greed and ease, or wake to sterile strife
While Bacon's vision waits, how long! how long!

THOMSON KING

SCIENCE, EDUCATION, AND THE FUTURE OF MAN*

By A. J. CARLSON

A former President of the A A.A.S., Dr Carlson (Ph D., Stanford, 1902) is so well and so widely known as to make a biographical note almost superfluous. He has been at The University of Chicago since 1904 and was chairman of the Department of Physiology from 1916 until 1940, when he became emeritus professor. The list of his honors, his travels, and his accomplishments is much too long to include here. Born in Svarteborg, Sweden, in 1875, Dr. Carlson still retains a piquant suggestion of Swedish accent.

WHAT factors shaped the human biologic and social evolution of the past—say, the past million years? We are familiar with the term and the idea of the survival of the fittest. It is a fact that all animal species, man included, tend to reproduce in any and all parts of the world to a point where the supply of available food becomes insufficient to meet optimum nutrition requirements, except as the increase in number of a species is checked by disease and by violence from within and without the animal species itself. Past evolution of man has accordingly been determined by factors still operating among wild animal species. Understanding of man and nature played no part, because man had no such understanding either of himself or of nature until practically yesterday. Science has now given us a great deal of reliable information on the nature of man, the factors of health and disease, and the nature of the universe about us. The question is, Can this understanding of man and nature modify, ameliorate, and improve on the crude, blind, and, we might say, cruel factors that determined past human evolution?

This important and very serious question dawned gradually on my thinking, stimulated largely by two experiences:

(*a*) We are now seriously concerned with the possibility of wreckage of our civilization by war and atomic bombs. It is a fact, so far as we can rely on history, that every human civilization of the past has "gone with the wind," even without the aid of atomic bombs. Was there anything in these temporary civilizations of the past—Asiatic, European, and American—that weakened the human frame, rendered man less able to survive? This question is at least as important as "Shall we, or shall we not, use the atomic bomb in our warfare tomorrow?" It deserves attention. I do not have the answer. Dr. E. A. Hooton, the Harvard University anthropologist, thinks he has the answer. I quote from Dr. Hooton's *Twilight of Man* (p. 192):

> Material prosperity encourages the preservation, pampering, and reproduction of the biologically inferior elements which are parasitical upon rich civilizations. Then some cleaner-blooded, and culturally crude stock crashes in and wipes clean the slate. Out of apparent evil comes eventual good, because the cultural and biological dross is destroyed so that man and civilization can rebuild themselves. Evolution, if it is to be progressive, demands the selection of the unfit and the culturally obsolete for extirpation. We can either prune off our own rotten brances or submit to a ruthless cutting down and thinning out by more vigorous conquering stocks.

This factor, stressed by Dr. Hooton as the cause of past failures of so-called civilizations, may be one element in some cases. I do not think it is the complete answer. In Rome two thousand years ago the slogan was "Bread and circuses." In our own country today some fellow-citizens insist on the slogan "Security from the cradle to the grave." Both slogans are unsound biology.

* From an address delivered at the inauguration of President Stoddard, of the University of Illinois, May 15–16, 1947.

Both are off the beam, as I understand man, past and present.

(*b*) On a visit to China some twelve years ago, I was brought face to face with two biologic incompatibles among the two hundred million people in northern China. One of these was the extensive undernutrition of many of the people, owing to the inability to raise sufficient food for the two hundred million mouths and stomachs. This situation exists despite the care of the land as indicated by fair crops, even after ten or twenty thousand years of agriculture; that is to say, the Chinese farmers have not decreased the fertility of the soil as fast in those thousands of years as we here in the United States have done in the past two hundred years. The second incompatible was this: So far as we have reliable vital statistics on northern China, the infant mortality among these two hundred million people is very, very high. I was told during my visit that one out of every two infants born in northern China died during the first year of life. This is a terrific waste. There is no question but that application of the principles of modern medicine in northern China would reduce this terrific infant mortality, this terrific waste, to the figures in those lands where modern medical science prevails. But suppose this modern medical science becomes available in northern China and these millions of infants are prevented from dying? All that means just more mouths facing starvation. This does not add up. I cannot conceive of a moratorium on advance in medicine and the control of infectious and epidemic diseases in all lands. But these diseases were important elements in eliminating the unfit or the less fit of our race during the past million years. What is to take the place of disease in human evolution tomorrow? Is it to be more war or more intelligence? I, for one, cannot see that breeding like rabbits is necessarily indicative of our name, *Homo sapiens*. We know now enough about defective hereditary factors in man to eliminate many tragedies and calamities, if we have the vision and the courage. As I look at it, to bring children into this world, children impaired physically or mentally through defective heredity, is cruelty to children. I go our late Chief Justice Holmes one better: I insist that three generations of imbeciles are more than enough.

Are we handling our soil, air, water, and other natural resources in the interest not only of today but of posterity, a hundred thousand years ahead? Ultimately, the healthfulness of our air and water and the foods produced on our soil and in the sea will determine our number, if not our health, our efficiency, and our happiness. We have, at long last, begun to think of soil conservation, even in my own state of Illinois. In the *Chicago Daily News* of November 11, 1946, there appeared an editorial under the heading "We Must Eat." This editorial discussed a meeting called by the bankers of Illinois to consider the impairment of farm land values in our state by failure to retain or restore fertility, and the investment losses of the banks through such deterioration of the land. I quote this statement from the editorial (without vouching for its accuracy): "Unsound commercial farming in the past has destroyed over 250,000,000 acres of American crop lands." John Fischer tells us (*Harper's Magazine*, May 1947) that

> Most Americans do not yet realize the ruinous speed with which we are stripping away our timber, our strategic minerals, our natural gas and oil, and the very earth itself. . . . This is no longer of interest only to a few wild-life enthusiasts and soil scientists; it has become a question of survival.

Chancellor Hutchins thinks that another hundred years of this thoughtless waste spells the end of our civilization. In a recent number of the *Daily Iowan* (Iowa City) there is a thoughtful editorial under the caption "They Can't Eat Guns," from which I quote: "Common sense tells us that

it would be a lot easier to sell democracy between two slices of bread than between two thicknesses of armor."

I lived on a farm until I was sixteen, and I have been around (with my eyes open) in many parts of the world in my more than seventy years. It took probably more than thirty to fifty thousand years to produce the fertile soil of Illinois, Ohio, Iowa, and Kansas. Now we have ruined tens of thousands of acres of fertile soil in three of these states by surface mining, to get out a few tons of soft coal for a few dollars per acre at the sacrifice of good crops for the next fifty thousand or hundred thousand years. Does that mean that we are looking ahead, that we are thinking of our children's children? In the face of this can we claim the name *Homo sapiens?* Man—that is, the human race—has dwelt on this earth at least a million years. It seems to me it is high time that those who would be wise should look ahead at the possible consequences of their individual, national, and international actions, not only today and tomorrow, but a hundred, a thousand, a hundred thousand years from now. As I see it, the person who has developed some control of his greed, his vanity, and his fears; who has developed to the limit of his brain the understanding of man and the universe achieved by science; who thinks in terms of his fellow-men—the human race—not for today, tomorrow, or even the next hundred years, but for a future at least as long as our human past; and who at the same time uses all his influence, without violence or coercion, to prevail on his fellow-men to follow his example—that man only is entitled to the designation "wise."

The minerals and other essential elements removed from the land with the food crops must obviously in the long run be replaced, unless we want to produce a desert. We are not doing this replacement adequately at present. I have seen American tourists, even college graduates, turn up their noses in derision and scorn at the farmers in France and Holland who took care to get the night soil back on the land. We are proud of our hybrid corn and the higher yield per acre of this product, but we have this higher yield at a period when it is not absolutely necessary for food and health of man or beast; and unless we replace the soil elements removed at the greater rate with the higher corn yield, we shall simply deplete our soil that much faster. India and China cannot now produce enough food for their seven hundred million people. Sir John Orr, Director General of the Food and Agriculture Organization of the United Nations, thinks that we must double the world's food production if the two and one-quarter billion people in the world are to enjoy an adequate diet. If we could do that—if we did that—what then? According to past records, increasing the food supply by better agriculture merely yields a parallel human population increase. England and Belgium must import much food to meet the needs of their people. The United States, Argentina, Canada, and Australia will soon have no food to export, however, unless the growth of the population is checked by war, disease, or the exercise of intelligence. The local populations will need all the food each of these countries can produce. Must we, then, fall back on the blind agencies of the jungle, disease and violence? Why not give understanding and intelligence a trial?

Modern industry is literally turning the earth inside out at a rate that never occurred in the past, except in the neighborhood of volcanoes. Modern industry is thus changing man's environment at a faster rate than ever before. Are any or all of these changes beneficial, indifferent, or injurious? It is true enough that adding lead to gasoline produces a mixture that keeps automobile engines from knocking. It is also true that the amount of lead thus spewed into the air, into the countryside, and into our streets, alleys, and homes is not enough as

yet to produce acute or chronic lead poisoning. But suppose we continue with leaded gasoline for another five hundred years, what is going to happen? That lead thrown into the air of country and city from the automobile exhaust does not disappear, it becomes part of the soil, the dust, and the water. And this is not the only source of lead thrown into our environment by modern industry. Lead arsenate is a good killer of insect parasites on our fruits and vegetables. The question is, In the long run will a worm in the apple be more injurious to human health than lead and arsenic on the surface of the apple? And there is some evidence that spraying with lead arsenate for as short a period as thirty years may seriously poison the soil for some vegetation. Similar problems face us tomorrow in connection with fluorine; that is, the increased use of fluorine in industry and the exposure of man, animals, soils, water, and air to this element. For, remember, when we drive off part of the fluorine in our rock phosphate for the soil, that fluorine is not driven into space, it remains on the earth as part of the human environment.

I, for one, will not be happy to contemplate war and violence replacing tomorrow the factors of disease and epidemics in limiting the human race on this earth. To be sure, war, with the aid of science, is gradually becoming a more effective killer and maimer of man. According to the recent estimates of the Harvard University professor H. M. Jones (*Education and World Tragedy*, 1946, pp. 7–9), in the first three decades of the present century, we killed by war 33 percent more people than were killed by war in the previous eight hundred years. Professor Jones asserts that if the entire population of the United States were wiped out tomorrow, this number of dead would be less than the number of people killed by war during the past half-century. But this wholesale killing of men by war may not reduce the pressure of overpopulation, because of the damage to man's biologic and physical environment from atomic bombs and biologic warfare.

As I view man in history, war is one of the most stupid of his activities. I am reminded of the highway signs put out in northern Michigan, Wisconsin, Minnesota, the Dakotas, Washington, and Oregon by the U. S. Forestry Service forty years ago. These signs read:

EVERYBODY LOSES WHEN FORESTS BURN

This applies to war. Everybody loses in war. No, war is not the answer. In this war (for we have not yet won the peace) we selected 60 percent of the ablest, healthiest, and most intelligent of our youths and trained them to kill or maim and to be killed or maimed. If a farmer selected 60 percent of his finest horses, cows, sheep, and hogs and forced them to be killed or maimed for no purpose, I think we would not call that farmer a wise man. Stopping medical progress and medical service is not the answer for our race tomorrow. We have the answer, at least in part, on the basis of present knowledge of man and the universe, both as to human reproduction and as to the care of the soil, water, and air. From all the evidence now available, it seems clear that in the past greed, guile, and violence had some survival value for primitive man. Assuming that these drives can be curbed on a national or international scale by new mores based on understanding, reason, and emerging justice, will the latter have equal survival value in and for the kind of society we hope to build? My answer is, Yes. But we must apply new and different measures to reduce the number of the least fit. We have enough scientific information to make a beginning in that direction now. Unless reason based on understanding effectively guides social evolution of tomorrow in the direction of elimination or reduction in number of the least fit—those who cannot

or will not strive for the individual and the common good—I see no escape from the degeneration that invariably follows biologic parasitism.

Assuming increasing control of infectious diseases, a decrease in the prevalence of war, and a not-too-rapid weakening of the human race by the reproduction and survival of the less fit, it seems clear that food will some day be the limiting factor of our numbers, if not of our health and efficiency, no matter how much more understanding we may gain of the interior of the earth, of subatomic energy, and of the supergalaxies in the distant heavens. That means that agriculture and foods are clearly must items in general education tomorrow. But why wait till tomorrow?

It seems clear that the answer to my more than $64 question is not to be found in the current three-R's curriculum of our schools nor in the "great books" of the past. Science itself has not yet given the answer, unless the answer lies partly in the evidence that the cerebral cortex, the latest addition to the human brain, has not yet acquired complete control over the ancient hypothalamus, the part of the brain that we have in common with the toad, the snake, the hyena, and the goat. But, if it is true that a man's social responsibility parallels his understanding of man and nature, the scientist and the educator are certainly on the spot, facing this question. Whether science and the scientific method, whether understanding, honesty, reason, and justice can through education contrive survival values equal, if not superior, to the blind forces of nature that shaped man's past, is as yet in the laps of the gods. Still, we cannot deny the possibility, and we shall nurse the hope that the hairy ape who somehow lost his tail, grew a brain worth having, built speech and song out of a hiss and a roar, and stepped out of the cave to explore and master the universe may someday conquer his own ignorance and irrational behavior.

There is some evidence that the dominance of emotions over reason and understanding in man may be due to functional rather than to structural brain factors. If this is the case, we may get somewhere with better general education. At least, we cannot lose anything by exploring this possibility. But whether we do or we don't, the educator, the teacher, is still on the spot. On the science sector, a course in the history of science as a part of general education, proposed by President Conant, of Harvard University (*On Understanding Science*. New Haven: Yale Univ., 1947), will be better than no science, but I do not think this or any other history course will adequately meet our needs. I think we must get closer to the grass roots of science, even in general education. Knowing man and the processes of learning and effective conditioning as I do, I believe that listening, seeing, and reading, must be supplemented by at least a minimum of doing. And when I speak of general education, I cannot conceive that training all our healthy youths in the art of killing and maiming their fellowmen is a wise element in such education either for today or for tomorrow.

The questions I have raised have no ready or easy answers. The picture I have outlined, though dark and sobering, squares with known and proved facts, I think. As I see it, there can still be better days ahead for man, if we think ahead, if we go to work and apply the understanding of man and nature given us by science. It seems clear that, in the long run, the practices of the jungle will not work for the best interests of a species provided with the human cerebrum. For it is easier to wreck than to build.

We hear much today about "One World," but not enough about "One Human Species." At least we do not always act, at home or abroad, as if we believed this proved biologic fact. Although the primary challenge of our sobering problems is to educators and scientists, the responsibility must be shared by all sane citizens.

THE COMPLEAT ANTIVIVISECTIONIST

By HELEN MACGILL HUGHES

Mrs. Hughes (Ph.D., Chicago, 1937) is Assistant Editor of the American Journal of Sociology, *oldest and largest journal in its field. She is also a part-time correspondent for* Time, *covering medical, scientific, and educational news. She is, besides, the wife of the sociologist Everett C. Hughes (University of Chicago) and the mother of two small children.*

A RECURRENT threat to any scientist whose work calls for animal experimentation is the zeal of the antivivisectionists. Some biologists have for years energetically fought them off, but there are many who have paid little heed to the campaign. Yet even among those most active in the fray there seems to be very little comprehension of the mentality of the antivivisectionist. It can be isolated and dissected by case study.

Three years ago a dramatic battle was fought in the City Council of Chicago over a dog pound ordinance. The vigilance of Dr. Anton J. Carlson, Dr. Arno Luckhardt, Dr. Carlos Reed, and others brought this to the attention of their colleagues elsewhere at the time; it is perhaps the best known of their many skirmishes. Though it is now only an incident in a conflict that has gone on for nearly a century, it is logically so like many such encounters in other places and at other, more recent dates that I shall treat this local campaign as representative.

As the city ordinance stood in 1944, a stray dog could be reclaimed at the Chicago pound upon payment of a dog license fee and the animal's board; it usually cost a little more than $8.00 to get back a lost dog. Unclaimed unlicensed dogs were either destroyed or released to one of the city's four medical schools at no charge. During 1943 the medical schools had been allotted 9,000 dogs—a number actually not sufficient for the war-connected research on malaria, shock and hemorrhage, and the like. And no school was in a position to pay for animals should the free supply be cut off. Meanwhile, the humane societies were destroying 18,000–28,000 dogs a year, many of which might have been useful as laboratory animals. The cause of the passage at arms in 1944 was a proposal in the City Council to amend the pound ordinance so as to lower reclamation charges to owners, stop the supply of dogs to laboratories, and put the administration of the pound in the hands of humane-society officers.

For months the Hearst paper in Chicago, the *Herald-American*, crusaded for the amendment; for Mr. Hearst, himself a convinced antivivisectionist, has made his papers, in whatever city they are located, the public vehicle of antivivisectionist sentiment. Consequently, it is an instructive exercise for scholars to read the Hearst editorials—even more so the Letters to the Editor—for they expose to the academic man as possibly nothing else can, the mind of his enemy. At the time of the great Chicago battle, the *Herald-American*, as the self-appointed organ of the antivivisectionists, made the issue of major importance in its columns. Readers were constantly exhorted: "Write to your alderman—and here is his name and address." The other papers in the city—the papers read by academic, professional, and business people—gave the matter notice whenever there was any news to report, doing so in a matter-of-fact way that gave little more than a hint of the dimensions of the sound and fury. Late in the summer the amendment was presented to the City Council. The hearings were riotous. The deans of the medical schools and other notable research

men attended one session with 1,500 of the city's medical students (most of whom were in Army or Navy uniform at the time), to protest any limiting of the supply of animals to laboratories. "Not in recent years," reported the *Herald-American*, "has Chicago witnessed such a turn-out of the propaganda forces of organized medicine, fighting desperately to keep the privilege of removing family pets from the city dog pound for dog torture experiments." The opposition, also out in force, brought forward a veteran of seventy-six bombing missions, who took the stand to declare that "the kids back home had a right to ask protection for his pet and that was one of the things he was fighting for." A performing dog was introduced into the Council Chamber and put through his paces.

A compromise amendment was eventually passed that lowered dog license fees and pound charges to owners reclaiming dogs and, at the same time, permitted the university laboratories to acquire unclaimed dogs under the supervision of a citizens' board. Some of the members of this board, who appear to neither slumber nor sleep, are vigorously exploiting its nuisance value; each time the board charges a school with neglect of its dog quarters, the fate of a whole research program hangs in the balance. The schools have always been able to clear themselves, however.

An important wing of the antivivisectionist movement is composed of people who have joined because they shrink from suffering. The prejudice against surgical procedures is an old one whose roots are probably in the medieval religious taboos against the mutilation of bodies. The sentiment was certainly understandable in the days before modern anesthesia, and it was then that the antivivisection movement had its beginnings, in England. Spokesmen of the movement insist that even today, however, dogs are operated on while conscious. "If the dog is not awake," asked one of them rhetorically, "what can the experimenters learn about his reactions?" And so the humane societies prefer to kill animals themselves rather than permit them to be assigned to laboratories.

In its insistence on the cruelty of research, the Hearst press has developed a dramatic glossary, in which "medical butcher" and "dog torturer" are synonymous with laboratory researcher; a laboratory is a "torture chamber;" any experiment at all, whether it be the injection of hormones or the feeding of vitamin pills, is "vivisection" or "dog torture;" and every unlicensed stray dog, "the family pet."

> Begin "The Chicago Chamber of Horrors" [ran a promotion squib], by a man who spent several months in a vivisection laboratory in this city. The abuses he has witnessed seared his soul. If you have any spark of humanity in your heart you will want to read "The Chicago Chamber of Horrors." Begin it Friday in the *Chicago Herald-American*.

This bloody chronicle, complete with "artist's drawings," turned out to be an account of doings in the Department of Surgery of the University of Chicago Medical School. Those were days when the school's astonished faculty could hardly wait for the paper to come out.

The language of this literature is violent because it is a recruiting talk, not an account of the day's news. But such appeals, though fanatically phrased, attract to the movement against research large numbers of tenderhearted readers. These become the moderates in the organization, the people who may never go to meetings but who will write checks for what appears to them to be a worthy cause. Dr. Luckhardt tells the story of a physician friend of his who was giving insulin to a small child. "Doctor," said the patient's mother, "I am writing my will and I have some money to bequeath to some good cause. I have been thinking about the antivivisection societies. What do you think of them?" To such a woman a

sick child is surely as moving as a sick puppy. That she should be so woefully misled as to think of subsidizing an organization that would have made the discovery of insulin impossible is not entirely her fault. For the puppy's protagonist is free to exploit the public prints in his behalf. Scientists, on the other hand, in appealing to the layman, are restrained by a characteristic fear and distrust of publicity. This makes it an unequal contest. But it does not need to be so. And, if they can contrive to escape this dilemma, the scientists can be confident of a fair chance to win over the more moderate fraction of the antivivisectionists. They might do worse than avail themselves of the strategy outlined several years ago by Mr. Hearst, who, it must be admitted, has a devilishly sure touch in manipulating the public. After the defeat of the Burdick Bill to abolish animal experimentation in Washington, D. C., he advised new tactics: "Don't have paid officials and costly quarters. Meet at home for tea, luncheon, or card parties. Begin in the neighborhoods as though you were getting up an outing club. Raise small funds and great personal interest. Appreciate your friends in the state legislature." This is a forewarning that the campaign will be marked by intense local enthusiasm rather than by impersonal national operations. And it calls for personal forcefulness and energy in the defense.

No one can doubt that there are many honest, sincere people in the movement, but, like most movements, it has its lunatic fringe, or, more accurately, its lunatic core, and this is the part most often and most vociferously heard from. It is noisy, inaccurate, illogical, and ignorant. It represents animal experimentation as reckless, needless slaughter on a heroic scale. A Dr. William Held, ignoring the fact that Sir Frederick Banting developed insulin at a sacrifice of just thirty dogs—a fact he must have known if he is, indeed, the "internationally famous Chicago physician" he is described as being—declared:

> Diabetes research learned nothing from dogs, as it is not the same disease in man. Cancer research is not helped by vivisection, as it is not the same in man and animals.... Harvey found the circulation of the blood by observing healthy human subjects. ... The step from animal to human vivisection is an easy one to the overenthusiastic researcher.

Much that is puzzling in the statements of the fanatics in the movement is made clear once the unstated major premise is grasped: namely, that a dog has the same moral value as a human being. If a dog is the equivalent of a man, then there is something at best unsporting, at worst callously selfish, in compelling the weaker creature to suffer in order that the stronger may be spared. "I would give my own body," cried a popular preacher who is an antivivisectionist spokesman in Chicago, "but I would not take advantage of a stray dog." Asked: "But if the facts learned from the study of a dog would save your child?" the answer is, logically enough: "Experiment on me. Or on rats, guinea pigs, or rabbits." It is probably a historical accident that cats, guinea pigs, monkeys, white rats, and hamsters are not assimilated in the antivivisectionist's conception of humanity. When Dr. Carlson asked a leader of the movement how she could bear to wear a fur coat or a feather in her hat, considering the suffering that must have been engendered, she replied, "I do not make pets of mink, squirrel, and pheasant."

The investing of a dog with a man's value explains the curious fact that, though they actually play the role of champions for animals as against those who would put man and his afflictions first, the antivivisectionists describe themselves as "humanitarians." This only adds to the semantic confusion occasioned by their appropriating the term "dog lovers" to denote themselves exclusively—though they some-

times demonstrate the perversity of physiologists by pointing out that the latter, too, have family pets. The result is to expose a group of scientists, already conceived of as cruel and powerful, as also just plain stupid and selfish.

In this eccentric phraseology a whole complex of sentiments is ventilated. In the Hearst papers, research men are often referred to as "the Bourbons of medicine" and the "Vivisection Bund." The presumed wealth, arrogance, and power of doctors is a persistent motif. "The pound," said a Chicago leader, "belongs to the people, not to any group. Why do doctors have access to impounded dogs? Lawyers can't go to our library and take out books for keeps." When the compromise amendment was passed, an editorial in the Hearst paper called it "... a triumph of human sympathy over entrenched conceit, tenderness over arrogance." This contrast between the plain, decent citizen who has no influence and the rich, potent member of a self-seeking, well-organized profession is a common and popular theme in mass publications. Mr. Hearst himself employed it when, in a column he supplied his own newspapers, he wrote about a dog who was flown to California to see his master, who had had to leave him to join the Army. The dog, he reported, had refused food since his master's departure and was kept alive during the journey by heart stimulants. On arrival the plane was met by "sentimentalists—a platoon of soldiers, a major and a colonel and unlimited lieutenants." "Are we," continued Hearst, "sentimentalists or sadists or saps?"

This depiction of the matter, with its social implications, wins for antivivisectionism a variety of people who are not so much interested in dogs as they are motivated by economic and political unrest. What they really hate is doctors, or scientists in general, or city life, or the modern world. A recent study of the Prohibition movement reveals that one element in it is a harking back to old days of simple rustic virtues, idealized as in Goldsmith's *Deserted Village*. The antivivisectionist might, with a small change in his circumstances, be instead a fanatical persecutor of Jews, a convinced Dry, an adherent of any social Utopian movement. Thus, the 1948 presidential candidate of the American Vegetarian Party observes that he hopes to have the votes of the vegetarians, prohibitionists, antivivisectionists, anticigaret groups, "and other people of similar high moral principle." The common quality among all these is that they are Utopians of a sort: people who quarrel with the moral code of the rest of the world and who seek to reconstruct society, beginning at some point of difference which may seem trifling but which in reality has deep significance in their eyes as the symbol of the great gulf fixed between this sinful, foolish world and a more perfect social order.

There may be many who happen to swallow the antivivisectionist bait—and not some other—because their friends have done so, or because the Hearst paper brings it to the breakfast table. That is not to say they are insincere; it is to locate as the root of their conviction, not an unrestrained sentiment for animals, but a basic uneasiness in modern life. For the antivivisectionist of the extreme sort is a moral revolutionary, a sectarian. Perhaps the sectarian mentality has never been better described than by Edmund Gosse in his *Father and Son*. Therein the father, P. H. Gosse, an outstanding marine biologist in his day and a colleague in biology but not in theology of Darwin and Huxley, is pictured as, before all else, an adherent of a fundamentalist Protestant sect. Always with his mind on higher things, he made life intolerable for his young son by inquiring each day whether the boy had remembered to question his schoolmates on the state of

their souls. This is inhuman, but the sectarian cares nothing for the human being as such. Whatever the movement he joins may be, he sees little in life beyond certain categorical phenomena. The man whose mission it is to attack modern science is simply not interested in the fate of diabetics or cancer sufferers; they are not the object of his concern.

The biologist, however, has set up as his chief end the study of physiological processes and the curing of disease, and animal experimentation is an incident of it. He very often makes the mistake of thinking the opposition shares his values and can be reached by persuasion, so he states his case in terms of lives saved. A prized item in his armamentarium is the argument that work on animals is saving animals, too. (Indeed, it is said that Hearst has never been able to secure antivivisection legislation in his own state because the cattlemen of California know that such work has brought about the cure of anthrax and other bovine diseases, and they always oppose it.) But this, again, is saying the reasonable thing.

The mind of the sectarian, or fanatical, antivivisectionist is, like that of the religious mystic or, more obviously, of the political extremist, not accessible to reason. He is, in respect to mentality, one with the Negro-hater, the Jew-baiter, and all defenders of doctrines of racial superiority, in whatever guise. But in this case science, or the medical profession, is the scapegoat. Now, it is very doubtful if reason is the best weapon, or even a weapon at all, against such minds. The point was made recently, *mutatis mutandis*, by Professor Leslie White, of the University of Michigan, who, in reviewing Franz Boas' *Race and Democratic Society* commented as follows:

> Boas fought race prejudice for almost a half-century ... Yet it cannot be said that Boas ever gave an adequate scientific explanation of racial antagonisms and I know of no evidence that will show that all of his efforts diminished race prejudice by one iota.... He proves again and again that differences in behavior between such groups as Jews, Negroes, Nordics, Chinese, etc. are not explainable in biological terms. But most, if not all, of this preaching is futile—futile because it is irrelevant. Race prejudice is not engendered by an ignorance of anthropometry or neurology and it is not curable, therefore, by a learned dissertation on these subjects.... Boas' attack upon race prejudice is like an attempt to rid a psychopath of the delusion he is Napoleon by demonstrating his belief is scientifically ... unsound. But the psychopath's delusion arises from other causes and sources; it merely expresses itself in this particular form (*Amer.J. Soc.* 1947, **52**, (4) 371).

Public-relations men have an axiom: you can win the argument and lose the battle. Not specific argument, but the building of good relations between research men and the public, is the means to make sure that science will not suggest itself as a scapegoat to the moral revolutionary. This is a hard task and one that has never seriously been considered. Under the attacks of the antivivisectionists, some research men have suddenly discovered the fact that learning itself has foes, just as organized medicine found out what some of the public thinks of it only when the Wagner-Murray-Dingell bills brought the matter into the focus of public attention. As a means of meeting the onslaughts of the most active and clamorous of the antivivisectionists, the cultivation of favorable attitudes in the layman is slow, but it is also, one hopes, sure and, many times, rewarding. The present leaders themselves will probably never be won over, but the propagation of their faith will be made more difficult.

VIVIPARITY IN TELEOST FISHES

By C. L. TURNER

Professor Turner (Ph.D., Wisconsin, 1918) has been in the Department of Zoology at Northwestern University since 1927. He has published numerous scholarly papers on viviparity in fishes. Those illustrations of the present article that previously appeared in the Journal of Morphology *are reproduced here by permission of the Wistar Institute.*

THE habit of retaining the young within or upon the body of the parent is one that has arisen independently and repeatedly among animals. External appendages, gill cavities, mouth cavities, specialized pouches, and parts of the genital tracts have been utilized as sites for embryo retention. The female parent is most often the one with which the young have become associated, but the male parent has not escaped entirely. In some cases he goes about with a bulging brood pouch upon his body, or his mouth is so filled with his own progeny that he is unable to feed during his period of oral gestation. It is not surprising that a group of animals as biologically plastic and currently successful as the teleost fishes should have developed viviparity as one of its many diversions.

The fact that viviparity exists among the teleost fishes has been known for a long time. Nearly two centuries ago communications from corresponding members of scientific societies of London and Paris who were visiting America reported new instances of viviparity in American fishes.

Since that time many isolated cases have been described, and a little more than fifty years ago the first monographic studies began to appear. Within the past twenty-five years more intensive studies have been made upon restricted phases of viviparity. It is probable that all the major groups of teleost fishes in which viviparity occurs are now known. A review of the literature indicates that at least eight of the large groups have developed viviparity independently and that, within single groups the members of which are chiefly oviparous, viviparity has arisen independently a number of times. A comparative study of viviparity in mammals and in fishes reveals that there has been a certain degree of parallelism in the evolution of the adaptations, but that there also is a surprising amount of diversity in the adaptations of fishes, including superfetation and, in some extreme cases, retention of young until they are sexually mature. Neither of these adaptations ever appears in mammals.

There seems to be no relation between the development of viviparity and ecological conditions. The livebearing habit is found in both marine and fresh-water fishes. It occurs in fishes living in the cold, lightless depths of the sea, in dark fresh-water caves, in shore habitats, in the tepid waters of tropical lagoons, in swift-running streams, and in the lakes of elevated, sun-drenched plateaus. Some live bearers are bottom-feeding minnows, others are top swimmers and surface feeders, and still others are swift, efficient carnivores.

A search for a relation between viviparity in fishes and geographic distribution reveals only that viviparity may occur in widely distributed families such as the surf perches, the rock cods, and the brotulid fishes or in small isolated groups that have very limited geographic ranges. The comephorid fishes found only in Lake Baikal in Siberia and the goodeid fishes occurring only in the waters of the Mexican plateau and immediate vicinity are examples of groups confined to restricted ranges.

The terms "oviparity," "ovoviviparity,"

and "viviparity" are used in most of the literature to designate, respectively, those conditions in which eggs are not retained in the body after maturity and fertilization; those conditions in which eggs are retained within the oviduct or uterus after internal fertilization, but are equipped with an adequate yolk supply, and no nutritive materials are supplied by the parent to the embryo; and that condition in which the retained embryos become attached to the uterus by means of a placenta and derive their nutritive materials from the mother. The terminology bears the implication that each condition is static and that all cases must fall within one or another of these categories. As a matter of fact, there can be no sharp distinction among the different types because so many instances of live bearing in teleost fishes are in the process of evolving from one type into another. Furthermore, very little research has been done on the kind and extent of interchange between embryo and parent, and so the extent of physiological dependence of the embryo upon the female parent is not well known. There is no true uterus in the teleost fishes, only a physiological equivalent, and there is no actual attachment of retained embryos to the tissues of the parent. In view of these facts, and since the evolution of advanced types and of intermediate stages of viviparity will be stressed in this article, the accepted terminology is not suitable for use. The term "oviparity" will refer to conditions in which eggs are evacuated from the body before fertilization, and the term "viviparity" will be used for all cases in which eggs are fertilized before leaving the body and are retained even for a short time. The term "ovoviviparity" will not be used.

STRUCTURAL BASIS FOR VIVIPARITY IN TELEOST FISHES

In reading an account of viviparity in teleost fishes, it is natural that one will have in mind the better-known mechanisms of mammals or of elasmobranch fishes (sharks, rays). In all vertebrates above the cyclostomes, except the teleost fishes, whether oviparous or viviparous, the process of reproduction begins with ovulation, a process in which the ovarian follicle containing a mature egg becomes ruptured and the egg is evacuated into the body cavity. The egg is drawn into the oviduct, which it traverses, and if fertilization is external it is extruded from the oviduct and the cloaca in an unfertilized condition. If internal fertilization occurs, the egg is fertilized in the oviduct. The egg may then be evacuated through the cloaca or may remain within a modified portion of the oviduct to undergo a short or a long period of uterine gestation. Placental associations are developed between the embryo and the uterus if viviparity is well developed. The uterine wall may remain intact or be deeply eroded in the formation of the placenta. On the part of the embryo, the structures concerned in the development of the placenta are a chorion, the yolk sac with its vitelline circulation, and the allantois, a saclike structure which evaginates from the posterior part of the intestine. One or more of the structures are concerned in all devices by which an interchange of materials occurs between embryo and mother.

The teleost fishes differ from all the above-mentioned vertebrates in a number of important structural characters that affect the condition of viviparity. In the first place, the viviparous teleosts do not have an oviduct. A short gonaduct extends posteriorly as a direct continuation of the muscular wall of the ovary, to open externally in the vent. When internal fertilization occurs, it must take place in either the gonaduct or the ovary itself, and embryos are harbored within the ovary or the gonaduct. The teleost fishes have never developed an allantois, and no allantoic (umbilical) circulatory system, which is so important in placental relations in the higher vertebrates, is ever

developed in the embryos. The vitelline circulation, including a network of capillaries upon the splanchnic covering of the yolk sac in the embryos of sharks and of higher vertebrates, is replaced largely by another network. The heart of a teleostean embryo lies upon the yolk sac, anterior and ventral to the body. All the blood that has circulated through the body must pass out of the body and through an elaborate portal network that covers the yolk sac and the wall of the pericardial cavity before it enters the heart. It should be emphasized that this is not the vitelline circulation of the other vertebrates, which, in some cases of viviparity, is important in the development of a yolk sac placenta. A structure that is a rough parallel of the chorion of the embryos of higher vertebrates occurs in the embryos of some teleost fishes. The pericardial cavity becomes expanded, and the somatopleural layer partially or wholly envelops the anterior part of the body by means of double folds. The external layer, the structural equivalent of the chorion in some other vertebrates, becomes vascularized by the portal network covering the yolk sac. The inner layer, a homologue of the amnion in some other vertebrates, is in contact with the body of the embryo. There is no amniotic cavity.

In brief, although the physiological requirements of the embryo in any well-advanced case of viviparity in a vertebrate must be similar, the embryonic structures and structural relations of the embryo to the mother in viviparity in teleost fishes are basically different from those that are concerned in viviparity in elasmobranch fishes and the higher vertebrates.

EVOLUTION OF VIVIPARITY IN TELEOST FISHES

The first step toward viviparity is intromission of sperm into the gonaduct. The males and females of many oviparous fishes bring the vents into close contact at the time of spawning, and the introduction of sperm through the vent into the gonaduct could be accomplished easily. It is necessary that the sperm be able to live, for short periods, at least, in the fluids of the ovarian cavity if internal fertilization is to be accomplished. In an incipient type of viviparity, ovulation would have taken place prior to fertilization, which occurs in the gonaduct or ovarian cavity, and after fertilization the fertilized egg, surrounded by its intact chorion, is extruded from the gonaduct quickly, so that little embryonic development occurs within the body of the female. Examples of this incipient type of viviparity are to be found in *Trachy choristes*, a Brazilian catfish, and in the phallostethid fishes of the East Indies. A climax case of viviparity, involving fertilization of the egg after it has been evacuated from the follicle into the ovarian cavity, appears to have occurred in *Zoarces*, a brotulid fish. Here the embryo is retained for a long period of time in the ovarian cavity, and evidence points to the occurrence of ovulation prior to fertilization. The ability of the sperm to remain alive within the ovary is partly a function of the ovary itself. In most cases in which viviparity has become well established, the epithelium of the ovarian cavity assumes a nurse-cell function, and the immobilized sperm becomes imbedded in the epithelium, to be kept alive for various lengths of time. In *Cymatogaster* the sperm are kept alive for months, and in *Heterandria formosa* live sperm are found in the ovary ten months after the female has had a single contact with the male. Long life of the sperm in the genital tract of the female has its parallels in reptiles and in mammals, but in these groups it is the oviduct rather than the ovary that provides the site for sperm retention.

The next basic step in the development of viviparity is the fertilization of the egg within the ovarian follicle before ovulation

has taken place (Fig. 1). Presumably this has been brought about by the earlier retention of sperm by the ovary and the harboring of the sperm in the ovarian epithelium. The ovarian epithelium is in contact with the wall of the follicle just before ovulation, and it would be necessary only for the imbedded sperm to penetrate the cells of the weakened follicle in order to reach the egg. Fertilization within the follicle prevents true ovulation. Since ovulation is controlled by a pituitary hormone, it would appear that some endocrine change has been brought about by, or is concurrent with, the new development of intrafollicular fertilization. Eventually, something equivalent to ovulation, namely, rupture of the altered ovarian capsule enclosing the embryo, must occur to release the embryo into the ovarian cavity, where it may be retained or extruded from the body immediately. The retention of the young embryo within the follicle sets the stage for further steps in evolution. Immediately after fertilization, the follicle cells that were concerned

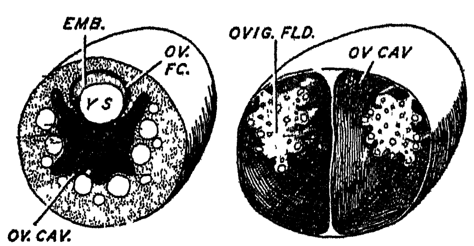


Fig. 1. Sections of ovaries to illustrate the positions within the ovary of embryo retention. In follicular gestation (*left*) the embryo (EMB.) with its large yolk sac (Y. S.) is retained after fertilization within the ovarian follicle (OV. FC.) and is evacuated at birth through the ovarian cavity (OV. CAV.). Gestation in the ovarian cavity (*right*, OV. CAV.) occurs in some forms after the egg has been fertilized in a follicle of the ovigerous tissue (OVIG. FLD.) and evacuated from the follicle into the ovarian cavity.

in the building up of the immature egg disappear or are radically changed, and the follicle is transformed into a vascular capsule that envelops the young embryo. The yolk sac, often a large one more than 3 mm. in diameter, is capable of providing food materials for a long stay in the follicle, but respiration and the elimination of wastes

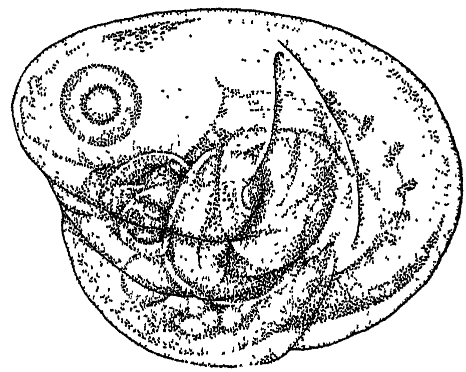


Fig. 2. A complete ovary of a poeciliid fish containing six small broods of embryos in different stages of development at the same time, to illustrate superfetation. The smallest spheres at the base of the ovary are embryos in the first stage of development.

must be provided for by an exchange through the permeable membranes of the follicular capsule and the yolk sac circulation (portal system) of the embryo. Once this physiological relation has been set up, the permeability of the membranes could be (and has been) altered so that nutritive materials may be conveyed to the embryo. This situation would be favorable for the concurrent reduction of yolk material in the egg and for new developments in the embryo and in the follicle wall that would increase the efficiency of the exchange of materials. This condition might be called "follicular gestation." This trend of evolution has occurred independently twice within the order Cyprinodontes. A parallel evolution toward reduction of yolk sac, with a concurrent development of new structures that provide efficient exchange between embryo and parent, has occurred in the mammals.

Another new direction evolution may take in fishes having follicular gestation is that of superfetation (Fig. 2), the condition in which two or more broods of embryos at

different stages of development are harbored within the follicles of the ovary at the same time. The condition has been evolved by the shortening of the period required for developing and maturing the egg. Apparently, a second group of eggs reaches maturity some time before the previous brood of embryos is evacuated from the follicles, and the eggs of the second group are fertilized, each egg within its follicle. In the same manner, other groups of eggs may come to maturity before the first brood of embryos is evacuated (Fig. 2). In the most extreme cases, seen in *Heterandria formosa* and in several species of *Poeciliopsis* and *Aulophallus*, as many as nine small broods, with their members in different stages of development, are found in the ovary at the same time. Effective superfetation, as far as is known, occurs only in the poeciliid fishes of the order Cyprinodontes, and in this family it has arisen twice independently. Effective superfetation does not occur in those vertebrates that have uterine gestation.

A second site in the ovary within which embryos may be retained is the ovarian cavity (Fig. 1). The type of viviparity involved in the retention of embryos in this position has arisen, except possibly in some brotulid fishes, from the older type of follicular gestation. The most advanced types occur in species in which the yolk sac has become greatly reduced. Conditions here are remarkably different from those in follicular gestation. The embryos are not separated from one another as they are in follicular gestation. They are all contained in a space lined by the epithelium of the ovarian cavity and bathed by a fluid secreted by the epithelium. Many of the embryos die and the bodies disintegrate. They are either absorbed by the ovary, or the remaining parts are ingested by the surviving embryos in a kind of intraovarian cannibalism. Gestation in the ovarian cavity is preceded by fertilization of the egg within the follicle. The egg is retained in the follicle for some time in *Sebastodes*, in the jenynsiid fishes, and in some of the brotulid fishes and is then evacuated into the ovarian cavity with the chorion still intact. In *Sebastodes* the retention in the ovarian cavity is short. The brood, consisting of thousands of embryos, is born to hatch and to develop thereafter in the manner characteristic of oviparous fishes. The period of retention in the follicle is very brief in the goodeid fishes, the embiotocid fishes, and some of the brotulids. The follicular wall breaks down and the chorion is ruptured while the embryos are in the segmentation stages, and the naked embryos are moved into the ovarian cavity. In those species in which the embryos are retained for a long period in the ovarian cavity after their evacuation from the follicle, there are some remarkable adaptations for facilitating the exchange of materials between embryo and maternal blood. The small yolk sac, sometimes quite minute, is quickly absorbed, and the food supply for later development must come from the mother. The embryos are retained longest in some of the surf perches (embiotocid fishes), the males, at least, being sexually mature when born.

The sequence of events in the reproduction and development of typical oviparous fishes is as follows:

1. Ovulation, during which the mature eggs are evacuated from the ovarian follices into the ovarian cavity.
2. Extrusion of the eggs, which are surrounded by an intact membrane, the chorion, to the outside of the body through the gonaduct and the vent.
3. Fertilization, which is external.
4. Hatching, which involves rupture and discarding of the chorion.
5. Larval development, during which the immature embryo leads an active life and is responsible for securing its own food and providing for its own protection.
6. Maturing, during which reproduction occurs.

In viviparous fishes the sequence of events is changed, and some or all of the events occur within the body of the female parent.

There are many modifications of the sequence, which is characteristic of oviparous fishes. Ovulation may be postponed until an encapsulated embryo has developed to the equivalent of a late larval stage in some poeciliid fishes, in hemirhamphids, and in *Anableps*. Fertilization has preceded ovulation, and, when ovulation does occur, it is followed immediately by hatching and birth. In different cases hatching may occur outside the body, within the ovarian cavity, or in the ovarian follicle. The stage of development at hatching may be that of early segmentation, early larva, or postlarva. The embryo finally evacuated from the body may be an egg which has just been fertilized, an early larva, or even a sexually mature fish. The endocrine controls of the processes of ovulation, elaboration of eggs, gestation in ovarian follicles, or in ovarian cavities, and birth of the embryos have been studied scarcely at all. It is obvious that a wide variation exists in these controls in the different types of viviparity in teleost fishes.

ADAPTATIONS FOR VIVIPARITY IN EMBRYOS AND OVARIES

In cases of incipient viviparity there are practically no structural features in either embryos or ovary that are notably different from those in oviparous fishes. In follicular gestation and in gestation within the ovarian cavity, there are some simple modifications of structure in cases in which the embryos have an adequate yolk supply for their periods of gestation. A striking series of new structures, which are temporary, exist only during gestation, and are associated with the exchange of materials between embryo and ovary, appears in cases of viviparity in which embryos have a small yolk supply. This is true of embryos harbored within ovarian follicles or ovarian cavities.

Follicular gestation. In simple follicular gestation the embryos are provided with a supply of yolk adequate for their period of gestation. The portal circulation upon the yolk sac and the pericardial sac is much like that found in oviparous fishes, but the pericardial sac is usually expanded as a sac or a hood, which is drawn over the head (Fig. 3). The follicular sac which encloses the embryo becomes fibrous and vascular while it surrounds the embryo, but there are no other changes in the ovarian tissue.

Follicular gestation involving embryos with small yolk masses is accompanied by the development of a number of extreme and temporary modifications in both embryos and ovaries. In *Heterandria formosa*, a poeciliid fish, a hood formed by the pericardial sac is greatly expanded, and the peritoneal

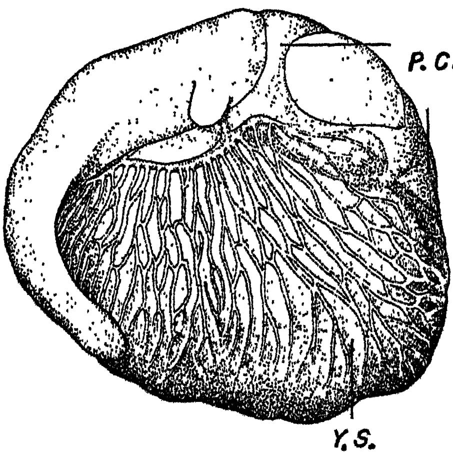


Fig. 3. Embryo of poeciliid fish with fairly large yolk sac. A part of the pericardial sac is drawn over the head in the form of a hood. The yolk sac (Y. S.) and a part of the sac containing the pericardial cavity (P. C.) are covered by a portal network.

sac also is enlarged. At an early stage the urinary bladder becomes expanded and pushes into the pericardial and peritoneal cavities. The diminutive yolk sac is absorbed at an early stage. The follicular wall becomes very thin, highly vascular, and closely applied to all the exposed external surfaces of the embryo. In *Anableps anableps* there is a great expansion of the pericardial and peritoneal sacs, and the portal circulation, which covers both sacs, develops

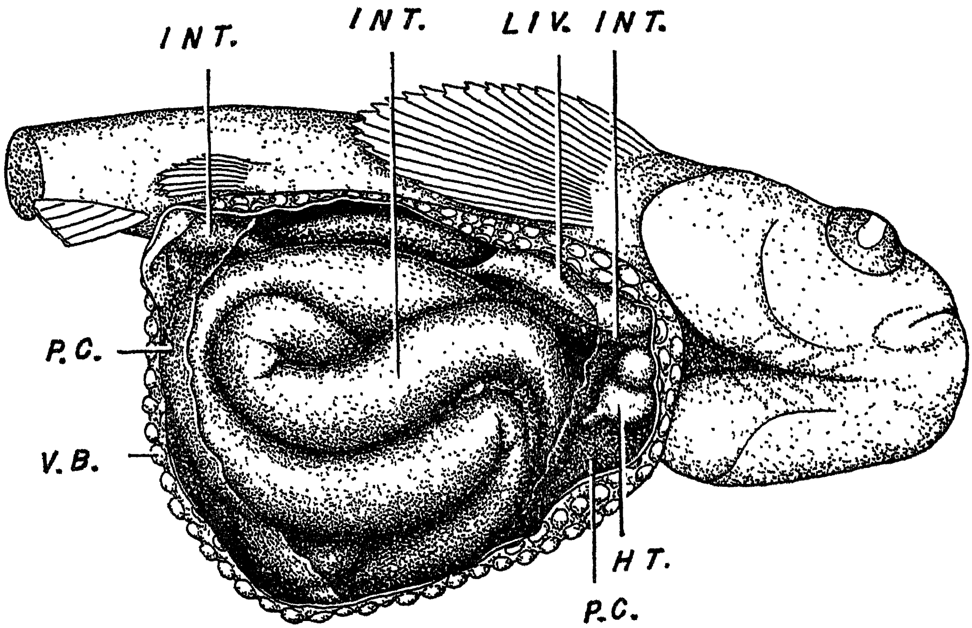


Fig. 4. Embryo of *Anableps* removed from the ovarian follicle. The enlarged belly sac has been dissected away to expose the internal organs Special features are: enlarged pericardial sac (P. C.), covered by bead-shaped enlargements of blood vessels (V. B); and intestine (INT.), the middle portion of which is enlaıged, elongated, and coiled. Liver and heart are indicated by LIV. and HT.

large bead-shaped protrusions, which serve to increase the vascular surface (Fig. 4). The middle portion of the intestine becomes elongated and develops long internal villi. Shortly after birth the elongated part of the intestine is absorbed. In another species of *Anableps*, it is the posterior portion of the intestine that undergoes temporary enlargement. The internal surface of the follicle surrounding the embryo puts out great numbers of fine, finger-shaped vascular processes (follicular villi). A loose placental relationship is thus established between the vascular wall of the follicle and the vascular surfaces of the pericardial and peritoneal sacs of the embryo (Fig. 5). Similar modifications producing an increase of the inner surface of the follicle are found in several species of poeciliid fishes.

Gestation within the ovarian cavity. All the instances, with one possible exception, in which the embryos are retained in the ovarian cavity have arisen from types which earlier in their evolution retained the

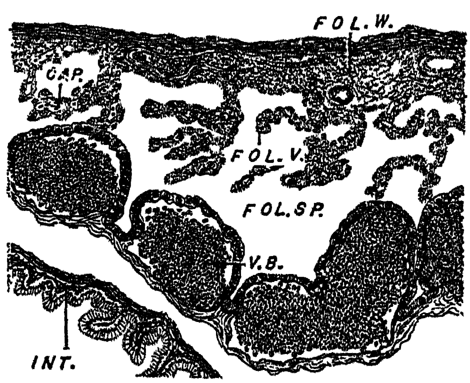


Fig. 5. Section to illustrate the relations between an embryo of *Anableps* and the wall of the follicle in which it is enclosed. The follicle wall (FOL. W.) is equipped with internal villi (FOL. V.), which contain capillaries (CAP.). A narrow space (FOL. SP.) separates the follicle wall from the external wall of the embryo with its rich vascular bulbs (V. B.). The enlarged intestine (INT.) lies in the body cavity.

embryos for some time within the ovarian follicles. The expanded and vascular peritoneal and pericardial sacs characteristic of the follicular type of gestation are present in the embryos for a short time and are reminiscent of the earlier type of gestation. These structures have a fleeting existence, however, and are quickly replaced by other new structures upon which the embryo depends later while enclosed within the ovarian cavity. Embryos of the jenynsiid fishes of South America develop enlargements of the peritoneal and pericardial sacs while contained in the ovarian follicles, but after evacuation of the embryos into the ovarian cavity there is a recession of the sacs. Later, flattened, leaf-shaped processes grow out from the walls of the ovary and become inserted under the opercula of the embryos. Further growth of the tissues of these ovarian flaps partially fills the gill and mouth cavities (Fig. 6). Shortly before birth the embryos are freed from the flaps. In the goodeid fishes of the Mexican plateau the early history of the embryos is much like that of the jenynsiid fishes, but after evacuation of the embryos into the ovarian cavity long, finger-shaped or flattened extensions grow out from the anal lips of the embryos (Fig. 7). The extensions are known as *trophotaeniae*. In *Parabrotula*, a deep-sea brotulid fish, flat, ribbon-shaped structures grow out from the region of the anus and the urogenital pore while the embryo is retained in the ovarian cavity (Fig. 8). One of the most remarkable of the temporary structures that are developed is a series of flattened vascular extensions of the soft tissues between the ends of the rays in the vertical fins in the embryos of the embioticid fishes (Fig. 9). In addition, the embiotocid embryo has a great expansion of the posterior portion of the intestine. *Zoarces*, a brotulid fish, has a parallel development of an enlarged intestine in the embryo during ovarian-cavity gestation.

Structural changes of a cyclical character occur in the tissues of the ovary during gestation. When the embryos are first evacuated into the ovarian cavity, the cells of the epithelium surrounding the cavity become high and columnar and their secretory activity is increased. At the same time the connective tissue of the ovary becomes swollen. Large numbers of free cells appear in the semifluid connective tissue. Somewhat later there is a general increase in the vascularity of the ovary, and a rich capillary network develops just beneath the epithelial lining of the ovarian cavity. Following the increase in vascularity, there is a general shrinking of the connective tissue. After the

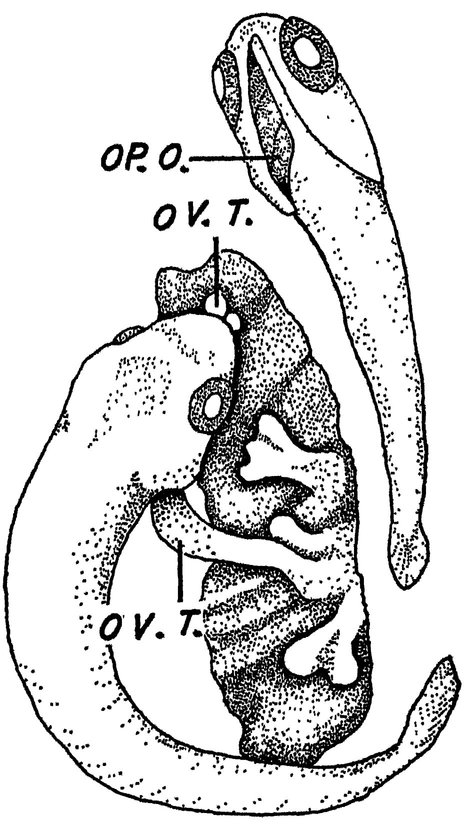


Fig. 6. Embryos of a jenynsiid fish removed from the ovarian cavity with a part of the ovarian wall. Leaf-shaped extensions of the ovarian wall (OV. T.) grow into the opercular openings (OP. O.) of the embryos and partially fill the gill cavities and mouths of the embryos.

embryos are born, the ovarian tissues undergo involution, and the conditions existing in the ovary prior to fertilization of the eggs are restored. Some of the blood vessels remain permanently enlarged.

variety of adaptive structures associated with viviparity in teleost fishes the techniques that have been employed in the study of the physiology of the mammalian placenta.

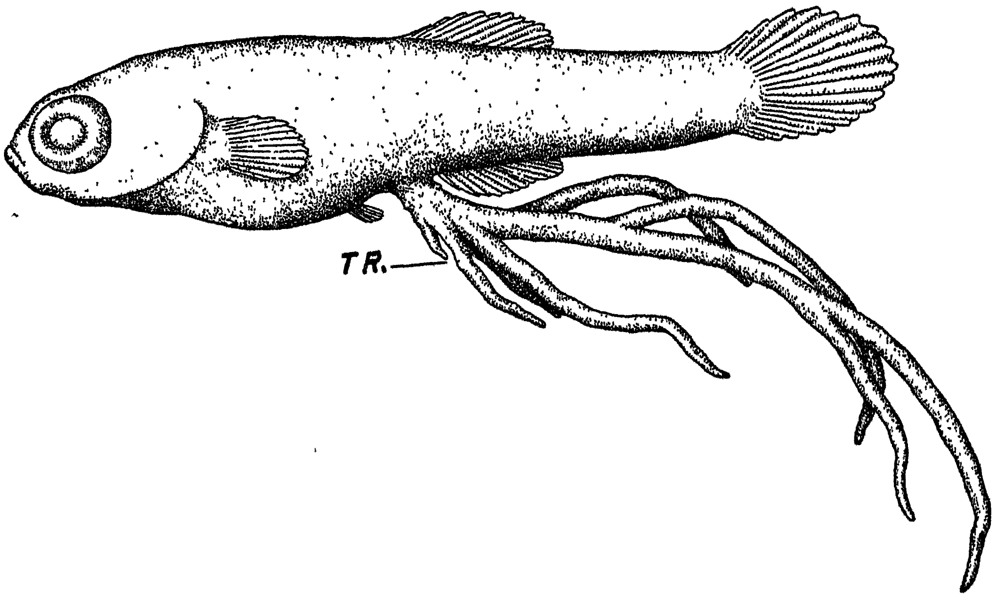


Fig. 7. Unborn embryo of a goodeid fish. After the embryos have evacuated from the ovarian follicles into the ovarian cavity and the previously enlarged pericardial sac has receded, the vascular trophotaeniae (TR.) grow out from the anal lip. These temporary absorptive organs are lost at birth.

PHYSIOLOGICAL INTERPRETATIONS

Any embryo harbored in the body of the mother for a considerable length of time is physiologically dependent upon the mother to some extent. If, during the period of retention, highly elaborate and unique structures are developed by the embryo or the ovary of the mother and these structures exist only during the period of gestation, it may be assumed that the temporary structures are associated with some phase of the transfer of materials between embryo and mother. There is little exact information on the transfer of materials, and most of the physiological interpretations are inferential. A field of research is open to any investigator who will apply to the bewildering

The most important physiological requirements of the embryo are those associated with the obtaining of nutritive materials, water, salts, and oxygen and the voiding of waste materials. It is generally conceded that nutritive materials are furnished by the yolk and that respiratory interchanges are carried out in vascular external coverings of the yolk sac and the expanded pericardial sac in embryos equipped with large yolk sacs. Nitrogenous wastes must either be voided by way of the parental blood stream or stored in a sac with a membrane impermeable to the wastes. In *Heterandria formosa* there is a great temporary enlargement of the urinary bladder during gestation, and it is possible

that urinary wastes are stored in it as they are in the allantoic sacs of some of the higher vertebrates. The absence of such specialized structures in other species would indicate that urinary wastes are voided into the follicles (in follicular gestation) or into the ovarian cavities and are then removed by absorption into the maternal blood stream.

In cases of specialized follicular gestation in which the embryos have very small yolk supplies, the portal system on the expanded pericardial sac is in a position to provide for

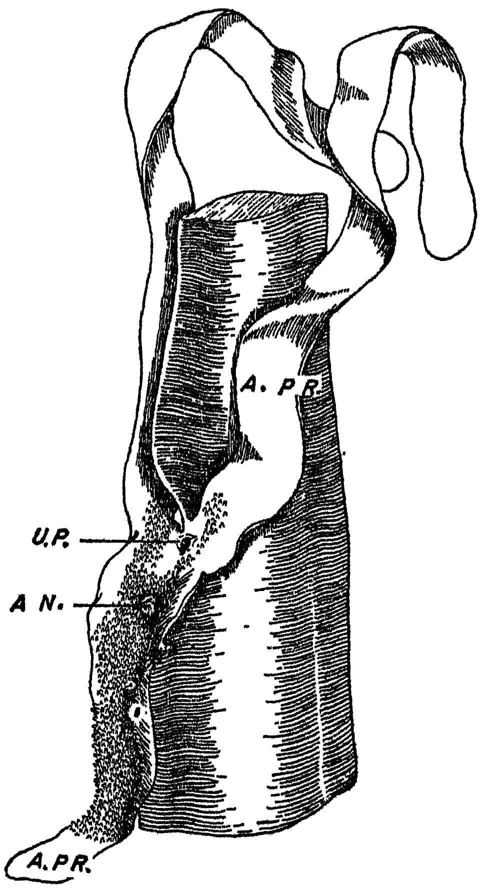


Fig. 8. Posterior part of an unborn embryo of *Parabrotula*, a deep-sea brotulid fish. The ribbon-shaped membranes, or anal processes (A. PR.), develop anterior and posterior to the anus (AN.) and the urogenital pore (U. P.). The membranes of the processes absorb materials from the fluids of the ovarian cavity in which the embryo lies.

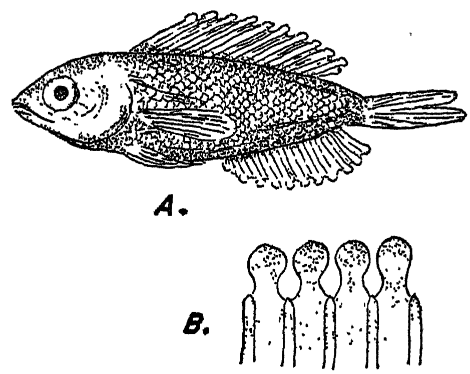


Fig. 9. *A*. Unborn specimen of an embiotocid fish. The male is sexually mature at this stage. *B*. Flat extensions of soft tissue between the ends of the rays of the vertical fins. These vascular protrusions are assumed to facilitate respiration.

respiratory exchanges with the maternal blood supply in the walls of the follicles. Nutritive materials must be obtained from the parental blood through the follicle wall. The highly developed glandular follicular villi in some poeciliid fishes and in *Anableps* suggest that the liquor of the follicular cavity is being continually enriched by secretions from the villi. The embryo may absorb materials from the follicular liquor by one or both of the following means. It has been observed in living specimens that follicular fluid is drawn into the branchial cavities of the embryos and is then passed through the alimentary canal. The temporary modifications of the alimentary canal during gestation in *Anableps* suggest that in this and probably other species absorption by way of the alimentary canal is the principal device by which the embryos secure nutritive materials. A second mechanism for absorption may be the portal system covering the pericardial sac. It is obvious that a considerable supply of nutritive materials must be secured by an embryo which has a yolk mass less than 1 mm. in diameter at the time of fertilization but has a length of 55 mm. at birth. It is obvious also that, being completely enclosed by the follicle walls, the embryo must obtain the

materials necessary for growth through these walls. The unique structures that occur in the embryo only during the gestational period are interpreted as the ones most likely to be concerned with absorption of the materials.

The lining of the ovarian cavity replaces the follicular wall as the maternal membrane with which the embryo must exchange materials in cases of ovarian-cavity gestation. In all cases of prolonged ovarian-cavity gestation the yolk supply is inadequate for the nutritional requirements of the embryo, and the pericardial sac, after a short existence as an expanded organ, is absorbed. It may be assumed that as long as the yolk supply lasts it is used for nutritional requirements, and up to the time of its resorption the surface of the pericardial sac is used in respiration and possibly excretion. Nutritive requirements are met, at least in part, after the absorption of the yolk and the pericardial sac, by materials ingested from the ovarian cavity. The material consists of masses of cells desquamated from the epithelial surface of the ovary, from secretion of the epithelium, from substances in solution that are derived by absorption from the maternal blood, and from dead and disintegrating embryos. Parts of the intestine of the embryos become enlarged, and their absorbing surfaces are increased by the formation of folds and villi. This feature is found in nearly all cases of ovarian-cavity gestation, and, since the groups in which it occurs are only distantly related, it must have arisen separately in the various groups. The general occurrence of an enlarged intestine and the finding of quantities of partially digested materials in the intestine lead to the conclusion that ingestion of materials from the ovarian cavity is the principal mechanism for obtaining nutritive materials. The other embryonic structures, such as the flattened fin extensions in embiotocid fishes, trophotaeniae of the goodeids, flattened membranes and fin folds of the brotulids, and the peculiar ovarian flaps that penetrate the gill cavities in jenynsiid fishes are probably concerned mostly with respiration. However, one or all of these structures may contribute to the performance of excretion or the securing of nutritive materials. A positive interpretation of the functions of these extraordinary organs must be postponed until they have been studied by techniques that will reveal the character of the materials which these specialized structures absorb or transfer to the tissues of the ovary.

BACK ISSUES WANTED

Receipt of copies of 1947 issues of The Scientific Monthly *for February—August, inclusive, will be greatly appreciated. They should be sent to American Association for the Advancement of Science, 1515 Massachusetts Avenue, N. W., Washington 5, D. C. Postage will be refunded.*—Ed.

Book Reviews

MAN MARKS THE EARTH WITH RUIN

Elements of Soil Conservation. Hugh Hammond Bennett. x + 406 pp. Illus. $3.20. McGraw-Hill. New York. 1947.

THE phrase "soil conservation," although extensively used in the past decade, is not of uniform definition or concept. In Dr. Bennett's book, too, confusion over this point prevails. In one place soil conservation is defined as meaning "using land efficiently under a farming system that safeguards it from erosion;" elsewhere it is stated that "soil conservation consists of safeguarding all kinds of useful land against impoverishment or depletion;" in still a third place, "soil conservation is, therefore, the scientific use of land." Such broad, diverse definitions as these detract from the main objective of the book, namely, soil-erosion control. Perhaps the title of the book might better have been "Elements of Soil-Erosion Control."

Of course, what constitutes a suitable title and range of subject matter on soil conservation depends largely on personal viewpoint, and, until concepts and definitions are crystallized, it is to be expected that a certain amount of confusion on terminology will exist. Certainly it would seem necessary to give more attention to soil fertility if soil conservation is to include the problems of soil depletion and impoverishment. The book does not discuss soil fertility, either in principle or in practice, and it is possible that some readers might erroneously conclude that control of erosion is all that is required to obtain high crop production.

Dr. Bennett urges that more science be used by the farmer in laying the foundation for the better use of his own and the nation's soil resources. He contends that many acres of our soil resources have been ruined or seriously injured by accelerated wind and water erosion. Through the application of scientific knowledge now at hand, or by gathering additional factual information, it is possible, he argues, to prevent or control excessive deterioration of our soil. To do this, he believes that it is necessary for the general public, as well as the farmer, to give greater attention to basic land facts. Some of these, as outlined in the book, are that our supply of really good land is limited, and that much of this really good land, as well as land of lesser quality, is subject to the wasteful process of soil erosion. With all these general arguments, serious students of our soil resources will readily agree.

On more specific points, there will not be such universal agreement. In one of the chapters on the erosion problem, it is pointed out that the early rapid settlement of our nation took a huge toll of soil resources, and it is implied that the pioneer settler had a "false philosophy of plenty." If the pioneer did make errors in clearing land for cultivation, it was because he was working with soil and climatic conditions alien to his experience, and it was on a trial-and-error basis that he proceeded. Even today neither our knowledge of soil-erosion control, nor our ability to apply it, is such that there will be no errors—perhaps serious and costly ones, at that—in the whole problem of proper land use.

What are some of the lessons that we have so painfully learned? That not all our soils

are suited to cultivated crops; that some soils are too stony, or too sandy, or too deficient in plant nutrients, or too droughty, or too sloping to grow grain crops in sufficient abundance for an adequate standard of living. We have also learned, as Dr. Bennett points out in How Erosion Takes Place, that wind and water are active causes of soil erosion. We have learned that both productive and unproductive sloping soils are subject to these relentless agencies. As also pointed out by the author, we have further learned that the rate at which the surface soil is lost depends on many variables: slope gradient, the nature of the vegetative cover, the properties of the surface and lower layers of the soil itself, and the intensity of wind and water factors. We have learned by controlled experiment, and by hard experience, that different kinds of soils require different practices to control erosion.

It seems to me that the author is somewhat too critical of agricultural scientists for failing to sense the "full effects of erosion." He implies, too, that soil depletion, land abandonment, and the migration of farmers are always related to erosion. This is painting far too simple a picture. It is a fact, also, that the soil-erosion problem was recognized by many agricultural scientists more than two decades ago. Lack of funds for research and education or the imperfect development of facts about soil properties can be said to be the main reasons for not accomplishing more in the solution of the erosion problem. If the early workers had expended all their available funds for research on soil erosion, it would have meant that little knowledge on the fundamentals of soil fertility would have been accumulated. Certainly knowledge of the role and use of rotations, lime, and fertilizers is of the highest importance to the low-cost, high-quantity production of food and fiber crops—and for the control of soil erosion, too.

Soil-erosion control involves, as Dr. Bennett says, a knowledge of plants, soils, climatology, and engineering; and, as far as is possible in a book of this brevity, discussion of some applied phases of these topics as they relate to certain soil- and water-management problems is included. Cooperation between different sciences, both basic and applied, is not, of course, a new concept or practice. In agriculture, as in industry, a team of scientists is often needed to solve many problems. But we should not forget that it is the highly specialized scientists who give us hybrid corn and improved strains of cotton, or who unravel the complex problems of soil fertility.

It is difficult, and perhaps too early, to determine to what audience this book will have the most appeal. Information in certain portions of the book, which is also available in numerous bulletins and journals, has already formed the nucleus of high-school and elementary college courses in soil-erosion control. Public officials and businessmen, as well as farmers, will find the book useful and will be able to obtain from it a better understanding of the nature, significance, and control of soil erosion. The many references to Federal and state agencies concerned with educational and research projects in soil conservation might perhaps have been more suitable in another book, say, one on the function and relationship of governmental agencies to a soil-conservation program.

Dr. Bennett is nationally known for his association with the Soil Conservation Service, but his long career in the United States Department of Agriculture is not so well known. Nearly forty years ago, he started as a soil surveyor, later becoming Inspector of Soil Surveys. His duties carried him to many parts of the United States, Alaska, and Cuba. His early and continuing interest in the problem of soil erosion led, in the late twenties, to the responsibility of organizing and supervising

a number of experimental farms for the purpose of studying how soil erosion occurs and methods for its control. Dr. Bennett, therefore, was a pioneer in the important task of preparing a scientific classification of the soils of the United States. His versatility in soil science enabled him to develop and administer the Soil Conservation Service of the Department of Agriculture, which is playing such an important part in a better agriculture.

F. F. RIECKEN

Department of Agronomy
Iowa State College

HISTORY OF SCIENCE

Benjamin Silliman: Pathfinder in American Science. John F. Fulton and Elizabeth Thomson. 304 pp. Illus. $4.00. Schuman. New York. 1947.

BENJAMIN SILLIMAN was a son of the American Revolution. Before him, in direct line, were John and Priscilla Alden. In his conscience still lingered a righteous Puritan heritage, though happily tempered by a sense of humor and a saving curiosity about life. At Yale College, where he graduated in 1796, he "experienced a spiritual rebirth that sustained him as long as he lived."

Silliman was tall and handsome, with manners gracious beyond his years. He would not be content "to walk obscurely along through some sequestered vale of life."

After graduation he studied law with the Honorable Simeon Baldwin. Six months after passing his examinations for the bar, Silliman became the first professor of chemistry and natural history at his alma mater. This is the strange beginning of the history of science at Yale, then resolutely orthodox, although it had been whispered that Ezra Stiles, once president of the College, had been "flirting with alchemy."

Fortunate it was that Silliman had been born "at the precise moment when his particular talents could be put to their most effective use." Whatever Silliman lacked as a scientist, he compensated for by his charm and his enthusiasm for science. With an unusual gift of expression, he captivated even those who saw in geology a foe to the Mosaic doctrine of creation. That he was able to reconcile the one with the other stood him in good stead, though Huxley once slyly remarked that Silliman wrote "with one eye on fact and the other on Genesis."

Silliman knew little or no chemistry. He obtained a few books, hid them in his desk, and occasionally read them privately. Soon he departed for Philadelphia to study. There he met Joseph Priestley, who "had become obnoxious to his native country on account of political and religious opinions." Silliman seems to have been a little impatient with Priestley, who forgot "that physical causes may be the moral agents of the Almighty." Returning to his "underground chamber" at Yale, he tarried but a brief time before setting out on a voyage to England, there to further the preparation for his teaching of science.

He found England in anxious preparation for invasion by Napoleon, who had massed formidable armies for crossing the Channel. Silliman saw Nelson depart to the glory and tragedy of Trafalgar. In London he found delight in the antiquities of the city, in the people he met, and in the theater, though he was somewhat shocked by the "indecent dancing" and the witticisms inscribed in the Poets' Corner of Westminster Abbey. He was troubled not a little, too, by "the instruments of gambling" he found in the hands of the Fellows at Caius in Cambridge. In Edinburgh he settled down to the more serious business of science.

Silliman was stirred by beauty as well as by truth. Not only did he find a cellar chamber for his laboratory and collection of minerals, but he also brought to Yale the paintings of the Revolution by the great

Trumbull and so encouraged an interest in the fine arts.

He labored long and arduously at his teaching and with his public lectures on science. These he carried to an ever-increasing audience of attentive and enthusiastic followers. It would seem, however that his son, Benjamin, Jr., took a slightly darker view of this part of his father's activities: "It seems like casting pearls before swine to take so much pains for those who for the most part appreciate it so little."

Silliman's *American Journal of Science* became the repository for the scientific thought of his time, and through it his influence reached across the Atlantic. He never lost an opportunity to increase the influence of science at Yale. His concept of science was utilitarian; he was "never an advocate of the study of 'pure' science confined within the walls of a laboratory—science for science's sake—he wanted to put knowledge in the hands of all who could do anything to promote its growth and usefulness."

From the pages of this book Silliman comes forth a figure with less depth and fullness than his achievements proved him to possess. His profile seems slightly out-of-focus. A child of his times, he thought as did his contemporaries, yet he saw beyond them. That he was not interested in science for its own sake, but rather in the practical employment of its work, need not have been cause for indulgent satisfaction. That was not the quality of Silliman that made him great. It was his defect. Had not his successors seen differently, the practical in science would long since have been exhausted, and science today would be sterile. What Silliman began, a few who caught his enthusiasm carried to new and more significant heights.

He conceived the first graduate school in America. Inadequate as it was, it nurtured some who were to create a new tradition. Silliman was but the link between the past and the present, however vital that link may have been. The new school he fostered allowed the student investigators "complete freedom to find their own way into the world of science." From this atmosphere there came two men of genius. One was J. Willard Gibbs, who was "probably the greatest scientist this country has yet produced." And there was also Daniel C. Gilman, who gave to America its first university.

Silliman's "ability consistently to win for science the support of the Yale Corporation, composed almost entirely of theologians, was phenomenal. Here he was notably aided by his strong religious faith and his personal warmth."

That Silliman was a deeply religious man there can be no doubt. Otherwise, in his time and in his place, he quite possibly would have failed. Yet Silliman was adaptable. It may be that too much emphasis is placed upon this quality, as if the same religious orthodoxy he so fully and honestly possessed might well be emulated by those who follow in his scientific footsteps. But this is beside the point of Silliman's life. May not his successors of today be as fully religious in their way as was Silliman in his? What humility must come to one who looks into the majestic and awful distances of the heavens, or into the microcosm of the atom with its equally awesome plan and order. Perhaps these men, too, as did Silliman, feel the mystery of the universe, even more fully than could their early predecessor when he beheld the revelations of the ancient prophets in a simpler age. But those who seek the truth today may find their religion no more static than their science.

CHESTER NORTH FRAZIER
School of Medicine
The University of Texas
Galveston

Comments and Criticisms

ERRATA

These comments concern two articles in the July 1947 SM. The first is S. H. Gould's "The Theory of Relativity and the Atomic Bomb," an interesting article, which, however, does not stay very closely with its title and which involves some misstatements of fact. On page 51 the author mentions "... Einstein's transformation, named after the Dutch physicist Lorentz... ." But the transformations mentioned are not originally Einstein's and were not simply named after Lorentz. They were first enunciated and employed by Lorentz, interpreted by Fitzgerald as a physical contraction in size, and were finally interpreted in a different way by Einstein.

Again, on page 54, the writer states that "Einstein ... assigns the motion of the Russian rivers, not to any absolute rotation of the earth, but to rotation relative to all other matter in the universe, and in particular to the immense masses of the stars." All this without any mention that it was Ernst Mach who first conceived and worked out such a theory of rotation, which was later included by Einstein in his theory and which incidentally is one of the weakest points therein. Such omissions are too reminiscent of those scientifically illiterate discussions which know only the much-publicized name of Einstein when it comes to relativity theory.

Third, the author is quite far behind the times in naively accepting (p. 60) the literal interpretation of the notorious relativistic paradox of the two travelers. This has long been explained in very clear and understandable terms based simply on the fact of the finite speed of light used in reading or recording time on each of the traveler's clocks. For a third clock at home base would record the same time lapse for each, and the travelers would not return one an old man and the other still young, as the common fallacy and S. H. Gould would have us believe.

The second occasion for our comment, the article "Man, the Myth-Maker," by Read Bain, is more serious both in its nature and consequences. On page 68 this writer states as his conclusion and suggestion that "a deliberate attempt to disseminate the scientific habit of mind widely, especially as it pertains to social phenomena, might hasten the decay of secular myths." Thus far, fine; but he continues with details of his conception of achieving this "Children could no longer be told lies and fairy tales—they would have to be oriented to the world as science sees it; religion would have to preach only such doctrines as are consistent with the methods [sic] and findings of science; artists of all kinds would have to eschew fantasy and espouse facts. . ."

And we read all the above example of a modernized form of bigotry after the author's admission on page 67 that "all single-factor, oversimplified explanations of social phenomena and remedies for social problems are mythic ... A man is myth-minded when he becomes obsessed by some particularistic methodology or theoretical point of view to the exclusion of all others. He is ready to brand other scientists as 'not scientists' if they do not share his methodological manias... ." No better illustration of these points could be found than the same writer's own passage, beginning "Children," etc., quoted above. Indeed throughout the entire article the author constantly resorts to name-calling, using the word "myth" and its variants as terms of ridicule and opprobrium to decry any and all who would not care to subscribe to his own brand of uncritical materialistic naturalism, which in point of fact is today becoming superseded in the philosophy of science, and actually represents a vestige from the nineteenth century.

A.A.A.S. has a section of its organization and membership devoted to psychology. It would be instructive to submit the passage in question to the scrutiny of several competent psychologists, requesting their opinion of it as a program for releasing scientifically the best in men's natures. I am quite sure their verdict would be unanimous in regarding Bain's well-nigh rabid diatribe a quite unscientific conception and one revealing a surprisingly intolerant attitude toward the whole vast realm of the imaginative and creative life of man, not important alone to art (which would shortly be stifled under such scientific fascism), but also to great scientific discovery.

An even more serious blunder is made (p. 67) in lumping "Marxism, capitalism, and democracy" as "ill-defined, all-inclusive concept[s] based on hope and fear." He may be right about the first two, but certainly democracy as historically evolved through the pens and actions of America's first great statesmen, the democracy of a Federal system of otherwise sovereign states that today provides the pattern

for world government and peace—this is far from ill-defined, for it means the brotherhood of man itself. It is not based on fear, either, but rather on the legitimate hope that such brotherhood may be a fact global in extent— our only safeguard for scientific progress, and indeed for humanity and social relations as a whole.

I deeply feel that the overwhelming majority of scientists worthy of the name do not share the polemic and uncreditable aspects of the views to be found in Bain's article, which, if carried to their logical conclusion, would tend to pervert scientific activity into intellectual arbitrariness and dictatorship.

CHARLES A. MUSES

Jackson Heights, L. I.
New York

THE ALUMINUM RULE

A couple of weeks ago I heard Professor R. A. Millikan take to the microphone—for true religion, of course. Since then, I have reread A. H. Compton's "Science and the Supernatural" (SM, December 1946). For two gentlemen who have had their differences, they do sound singularly alike. One wonders: does their explicit contradiction on the objective level of science perhaps reflect an implicit contradiction on the subjective level of religion, despite appearances? Such is indeed the case. But as Hegel said: it is not the contradiction of the idea by reality which constitutes the error; it is the contradiction of the idea by itself.

It is fairly clear that in Millikan and Compton, we have two Millikans, two Comptons; one private, one public; one religious, one scientific. Each unquestionably claims an equal right to each kind of belief. Nevertheless, the inner logic of their position compels them to arbitrarily bridge the gulf of their dualism. They do make public their private beliefs; they do afflict and invade my privacy, for instance, with them. "Truths" grounded upon subjective verifications thus become guilty of trespassing. Only objectively verifiable, scientific truths are entitled to the public places. If it is retorted: "Read, write, and speak and live your own beliefs," the point is precisely demonstrated; for then, logically, only violence can become the common ground for contradictory beliefs so founded.

Pietism, however diluted for the sake of plausibility, is anything but the virtue it presumes to be; it is simply latent conflict, self-conflict generating the smoke of self-deception. It does not comprehend the relativism of the private-public, the subject-object relationship. Whatever its ontological or epistemological forms, it directly stems from one "absolute" principle recognizable to every man: between the individual interest and the public interest there lies an impassable gulf.

T. V. Smith, in another article in the same issue of SM (having nothing to do with Millikan or Compton), reproved the invasions of privacy of the Compton-Millikan variety. Smith pointed out their self-contradictory character, but beyond that, he, too, had little to offer. When last observed, he seemed headed straight for solipsism—with only his own inconsistencies standing by to save him. His conception of the self, though less mechanical than the others, nevertheless assumes the character of an inviolate particle, the ultimate measure of itself, its fellows, and the surrounding field. Compton and Millikan believe unabashedly in having their cake and eating it, too; they seem comparatively expansive with the stumps of their dualism to limp about on. Smith is contractive, refusing to either have or eat his cake, but preferring to snitch small pieces of it when nobody is looking.

These errors, several in form but identical in content, all result from assuming the subject as the fundamental entity, and the subject-object as the fundamental relationship. The resulting humanism, thus set the task of determining its own basis—and therefore itself—can then proceed with its own destruction.

M. M. KLEIN

Arlington, N. J.

EXCEPT YE UTTER BY THE TONGUE...

Concerning semantics and some of the so-called sociological articles in the MONTHLY during the past few years:

You snap on the radio: Fighting in Greece. Fighting in Palestine. Fighting in Burma. Fighting in Java. Fixing to fight elsewhere. A lady missionary—missionary, that is—from Boston keeping a Negro slave in California. No, not a lay lady from Atlanta keeping one in Mississippi.

Myths? What do you mean by myth?

Most scientists who do not carry Sunday-go-to-meeting divinity on one shoulder and Monday-go-to-lab "definity" on the other will agree with quite a bit of Dr. Read Bain's article, "Man, the Myth-Maker," in the July SCIENTIFIC MONTHLY. That is, as far as the good doctor of sociology is objective. But when therein he scintillates subjectively he may allow very little thinking left for man to do except as a post-Hoover ultrasociologist.

Take a word: for example, "integrate." When a mathematician says, "Integrate!" why you just go

ahead and integrate; even if you have to twist and squirm or have to fall back on Lebesgue and Stieltjes But ofttimes in gobbledygookland, when one may be up a stump, one just beats one's breast with, or mumbles, "integrate." Let clinical controls and clean-cut definitions of terms go hang

And with deep scientific humility I hope some altruist of relatively recent etymological leanings doesn't "implement" me with an "elementary audit of the mass media" which "stem" from the "content analysis" of "accurate summations of multi-million-word-and-image barrages." S'help us!

Shades of the refreshing clarity and pointedness and masterful simplicity of the language of, say, Thomas Huxley's "On a Piece of Chalk."

PAUL B. WILLIAMSON

New Orleans, La.

COPPER

The August issue of SM carried an interesting article by Professor Benjamin Moulton entitled "Copper Resources of the United States," with a series of charts that were most informative and certainly of general interest in view of the importance of the reserves of this metal to all our citizens. In the main I am in close agreement with Professor Moulton's summations, but I beg to take sharp issue with his review of the situation in Chile, where I resided during some eight years. Dr. Moulton states: "Other refineries are located in areas having ample amounts of available water power. Thus, there are refineries at Chuquicamata and Potrerillos, Chile, as well as at Tacoma, Wash., and Great Falls, Mont."

It seems a pity that a professor of geography should have made such a statement as this, for Chuquicamata is situated in one of the most absolute deserts in the world, where it is not only impossible to secure water for hydroelectric power but difficult and very costly to secure potable water for the townsite, to say nothing of the water that must be used to leach the ore and freshen the electrolyte in the electrolytic refining process. Fresh water must be piped in a distance of about fifty miles from the high cordillera to the mine and plant. As to power, this is developed at the coastal town of Tocopilla, using petroleum which, up to the war at least, was brought down from Mexico in tankers.

Chuquicamata is unique among all the copper mines of the world, not only that it is so much greater than anything of the kind in the United States, and that the ore is high-grade, but also that much of it occurs as a binder of copper sulfate in a sandstone matrix. Just as it would be impossible to mine nitrates in nearby saltpeter deposits if there were any rain to dissolve out the salts, so is it equally difficult to imagine that a mine of soluble copper salts could long resist such precipitation as would be necessary to supply water for hydroelectric purposes The very fact of solubility of the ore makes it possible to by-pass the usual tedious steps that are necessary to carry the sulfides from the raw state up to the blister copper which is cast into anode bars for refining. Chuqui ores are merely leached with a solution of weak sulfuric acid, containing some copper sulfate to aid dissolution, since excess sulfate radicals in solution accelerate this step, the resulting liquors being the electrolyte, which may be treated directly in the refining tanks. Thus, the only output of copper is in a refined form that can readily be cast into wire bars for the electrical industry. In other words, it is easier to produce refined copper than any other kind of copper, which also explains the fact that Chuqui has shipped copper directly to Europe without additional beneficiation in the United States

Much may be said for locating a refinery close to cheap water power. This justifies Professor Moulton's reference to Great Falls, Mont. However, Tacoma, for all its proximity to water power, was designed primarily to handle foreign ores that could be shipped in by water without paying transit charges through the Panama Canal. It is primarily a smelter rather than a refinery and handles too small a volume of electrolytic copper to compete with larger refineries in the East, which are equally near tidewater and enjoy proximity to the larger coal fields. Professor Moulton might have mentioned the large refinery of the Phelps Dodge Copper Corporation in El Paso, Texas, which is also distant from the copper manufacturing trade. This refinery is also distant from cheap water power and operates on natural gas from the Panhandle fields.

Other factors than water power also determine the location of a refinery. The Braden Copper Company, in Chile, another large copper producer, does not refine its product, even though its sources of cheap water power on the Río Cachapoal are virtually beyond computation. The reason is quite simple: the ores carry values in the precious metals entirely too meager to warrant labor costs of refining the blister electrolytically. Convertor copper, given a certain amount of fire refining, can be purified to a point where it is quite acceptable to the manufacturers of alloys and is still malleable enough to serve quite a number of other uses. Hence, Braden copper, too, can be shipped directly to Europe without preliminary treatment at refineries in the United States. With the two principal Chilean mines equipped to act independently of facilities in the

U. S. A., it is not strange that the principal imports into this country have been, in line with Professor Moulton's statement, in the form of untreated ores rather than pig copper; the quantity, also, up to the time of lifting the copper tariff, has, quite naturally, been correspondingly small.

P. R. GLEASON

Middle River, Md.

BACK INTO BALANCE WITH NATURE

As a faithful reader of the MONTHLY, I have now and then a desire to express an opinion. Not being a Ph.D , I scarcely aspire to contribute an article but might enjoy seeing what I offer in your published letters to the editor; as a matter of fact, these are usually more interesting than the articles, I find, being more uninhibited and less formal and pontifical.

What I wish to note is that, while I believe that our future welfare lies in the hands of scientists, this does not necessarily connote that we are to be saved by formulas and synthesizations, but rather because scientists face the sum total of proven facts and refuse to be dissuaded by any form of fancy or hysteria.

I am a humble worker at conservation: "soil-water-and-life-itself," as we speak of it amongst ourselves After a decade of effort, I am fully convinced that we originally attacked "erosion" as the obvious ailment, whereas soil destruction and decline are merely symptoms of a deep social disturbance amounting to disease. Our job in the end is to preserve human life, and this will be done only by getting human life back into balance with nature and the rest of the life complex. We do find that the phenomena of human, vegetable, and animal life are inseparable and that the life complex is a vast symbiosis; soil seems to be the likewise inseparable foundation for the whole complex.

One way I think of the human problem is that our difficulties hinge on this gift of intelligence—or, perhaps better, articulate intelligence—which we alone seem to have: having it we must use it fully or it will destroy us. Nature is a vast and endless experimental laboratory, as is shown by what we call "evolution." In the slow course of time a great many species and genera and even forms of life have been discarded, and there is no reason to believe that man cannot deal himself out of the game unless he uses the talents that have been given him.

Intelligence would seem to have made obsolete the old game of a struggle for existence and the survival of the fittest, by making us aware of the possibilities of cooperation and symbiosis. This is why feudal individualism is being replaced by democracy, or at least efforts in that direction. Yet we still find that intelligence may only be maintained and advanced by the preservation of freedom for the individual. I do not argue in favor of any ritual or formal approach, but rather for complete use of intelligence and the irreducible minimum of inhibitions. I do believe that, if we all used our intelligence and faced the facts, our social problems would become negligible. Greed and urge for power over one's fellows are completely unintelligent. Humility is the primary attribute of intelligence.

What I should like to advocate is a much greater and more concerted effort toward coordinating all our knowledge with the whole Nature complex—making knowledge in vivo rather than in vitro, as I might paraphrase it—and a continuous effort toward simplification and lucidity in published dissertations. I remember what Sir Henry Deterding said some years back: that anything workable is simple and understandable by almost anyone, and that anything abstruse and complex might better be tossed into the wastebasket.

LAURENS C. BOLLES

Albuquerque, N. M.

ODE TO THE SCIENTIFIC MONTHLY

Oh, SCIENTIFIC MONTHLY, *sagacious publication,*
Full of facts and figures and precise information,
Edited by Campbell, of the A.A.A.S ,
And published every month at the Waverly Press,
Guided by the judgment of such eminent men
As Adams, Miles, and Mather, Robbins, Soule, and Flynn,
What chance have I, a medical neophyte,
Of writing for a journal so fully erudite?
What know I of radar or ornithology
Or spectroscopes or cyclotrons or cosmic astronomy?
And if I wrote of atoms or intricate molecule
I would only leave myself exposed to ridicule.
So how can this meager, embryonic M. D.
Get something published in THE SCIENTIFIC MONTHLY?
Unless it be these lines of wistful poetry.

EDWARD B. SINGLETON, M.D.

University Hospital
Ann Arbor, Mich.

Technological Notes

Important Scientific Instrument. Every school has its legends and traditions, including the sayings and behavior of some of the professors. The quotes most often handed down and longest remembered—by me, at least—are gentle plays on words and quizzical humor about the meanings of things said or written.

The reason I am thinking about this emphasis on expression, a trait more common in the older men than the younger, probably, is that I have just come across some releases which use the word "science" in a way I find slightly objectionable, though it is common enough in what passes for popular scientific speech and writing.

Professor Billy Evans, long the favorite lecturer on chemistry at Ohio State, was particular about definitions. "Science," he used to tell us, "is classified knowledge." We learned that science is information on which we may base a conclusion or action, but science itself—that vast fund of knowledge so often referred to with awe and reverence—would not itself be capable of action or decision.

And yet, falling into the habit of the popularizers, the National Geographic Society issued a release beginning "Nicaragua, current scene of a presidential shakeup, contains the only fresh-water lake known to science in which big salt-water fish abound." It is Lake Nicaragua, 100 miles long and 105 feet above sea level, and it contains sawfish, swordfish, and tarpon.

And General Electric, which should be more precise in its language, informed the papers last summer that "Science employs six main types of intricate machines to bombard the nucleus of the atom in an effort to make it give up its secrets." These are—might as well give the information while we are about it—the betatron, synchrotron, electrostatic accelerator, or Van de Graaf machine, cyclotron, synchrocyclotron, and linear accelerator.

In the room where Professor Evans used to do his lecturing on chemistry in particular and science in general is a quotation attributed to a colleague of his, now emeritus also, Professor C. W. Foulk: "The English language is the most important scientific instrument at your disposal. Learn to use it with precision."

That quotation is a good one for writers of releases and radio scripts, as well as for science popularizers and ad men. We all need to keep it in mind.

Dr. John Merrill Davis, president emeritus of Rio Grande College, gave me a gentle prod in the direction of exactness long ago when I was in the preparatory department of that little south Ohio school. I had done some typing for the doctor, and the bill, as I told him, was "about fifty cents." Saying I had charged him "about 49 cents," that was what he paid me.

Professor C. E. Sherman, who taught civil engineering in particular at Ohio State and English and life in general, once did some chuckling over a statement in a colleague's book on American history: "The battle of Point Pleasant was held October 10, 1774." Sherman sent the author a note and asked if invitations were sent out.

A legend about Professor Jimmy Boyd, of Ohio State's mechanics department, expresses it in a nutshell. "Young man," barked Jimmy, in the voice he had developed by teaching above the clatter of the machine shop, "you want to git all the English you can git."—M. W.

The Brownstone Tower

DURING the past three years in which I have written The Brownstone Tower I have shown to Dr. F. R. Moulton, our Administrative Secretary, the copy for nearly every issue before sending it to the printer. His approval was not required, but I wanted his advice, and he never failed me. Always he pointed out the rough spots in the copy and more than once he caused me to toss the copy in the wastebasket and rewrite it. I have never had a keener or a kinder critic. Dr. Moulton will not see this copy because I want to write about him in connection with the forthcoming Chicago meeting of the A.A.A.S.

In his seventy-sixth year Dr. Moulton will return this Christmas to the city in which he once shone like a supernova. He will return to Chicago as the administrative leader of the A.A.A.S., to which he has quietly devoted himself during the past eleven years. Only those who have worked with him, as I have, know how diligently he has toiled for the Association.

What has Dr. Moulton done for the Association? Let me mention a few of his personal contributions. He wrote the text of the *Proceedings* of the Association (1934–40), saw it through the press, and made it pay for itself. He wrote and delivered a long series of radio broadcasts on science. He initiated the "Symposium Volumes" of the Association—one of his most important services to science and the Association. He selected symposia worthy of publication in book form, edited hundreds of manuscripts for the preparation of more than twenty volumes, made arrangements for their production and sale, and came out in the black.

Because *Science* did not reach all members of the Association, Dr. Moulton initiated the eight-page *A.A.A.S. Bulletin* in March 1942. It appeared every month until December 1946, when it was temporarily discontinued. Through the *Bulletin* all members of the Association received information about the A.A.A.S. and its affiliated societies. Dr. Moulton wrote most of the copy for each issue, and his meaty editorials, each one skillfully written, were widely appreciated.

As long as the SM needed his editorial help, Dr. Moulton gave much of his time to it. He was a coeditor of the SM from 1939 to 1943. Many contributions from him are to be found in it. He engineered the difficult task of transferring the operation of the SM and of *Science* from the Cattells to the A.A.A.S. in Washington. To house the editorial and business offices of the Association under one roof, it was necessary to leave the Smithsonian Institution. Dr. Moulton set in motion a building fund campaign, and with the money so obtained, plus the savings resulting from his economical operation of the Association, our present building and our future building site were purchased.

I hope these few words will prompt our readers to realize that they have a devoted, farseeing, and courageous Secretary. He should be honored in Chicago where, at The University of Chicago, he gained scientific renown in celestial mechanics from 1896 to 1926. Never afraid of doing the unusual, he resigned from the University in 1926 and remained in Chicago for eleven years as an officer of Utilities Power & Light Corporation. During that time he continued to write scientific books and performed a remarkable public service during the depression as the Director of Concessions of the Century of Progress International Exposition. In opening the fair he hitched it to a star, Arcturus. But his feet were, and still are, on the ground.

F. L. CAMPBELL

INDEX

CONTRIBUTORS

PRINCIPAL ARTICLES

ALLISON, SAMUEL K.: Institute for Nuclear Studies, 482.

BAIN, READ: Man, The Myth-Maker, 61.
BARTON, SAMUEL G.: It's a Date, 408.
BLISS, S. H.: In Due Proportion, 70.
BRIDGMAN, P. W.: Scientists and Social Responsibility, 148.
BULLARD, FRED M.: The Story of El Parícutin, 375.

CARLSON, A. J.: Science, Education, and the Future of Man, 498.
COHEN, FELIX S.: The Role of Science in Government, 155.
COLBERT, REAR ADMIRAL LEO OTIS: Hitching our Country to the Stars, 372.
CURTIS, FRANCIS D.: Otis William Caldwell, 1869–1947, 495.

DELLINGER, J. H.: The Ionosphere, 115.
DENNY, MARGARET: The Royal Society and American Scholars, 415.

ESPENSHADE, EDWARD B., JR.: Problems in Map Editing, 217.
EVERSULL, FRANK L.: Korean Scientists Organize, 243.

GABRIELSON, IRA N.: The Fish and Wildlife Service, 181.
GARRETT, HENRY E.: Negro-White Differences in Mental Ability in the United States, 329.
GOULD, S. H.: The Theory of Relativity and the Atomic Bomb, 48.

HEDGPETH, JOEL W.: The Steamer *Albatross*, 17.
HIRSH, JOSEPH: The Research Council on Problems of Alcohol, 231.
HOCKETT, ROBERT C.: The Progress of Sugar Research, 269.
HUGHES, HELEN MACGILL: The Compleat Antivivisectionist, 503.
HUTZEL, JOHN M.: Arranging Meetings of the A.A.A.S., 234.

JANSSEN, RAYMOND E.: Crumbling Rocks, 103.
JEFFRIES, ZAY: The Efficient Utilization of Metals, 325.

KEITH, P. C.: Progress in the Transformation of Energy, 207.
KENNEDY, CLARENCE H.: Child Labor of the Termite Society versus Adult Labor of the Ant Society, 309.

LARSON, C. THEODORE: Toward a Science of Housing, 295
LEVENSON, LEONARD H.: Criminal Law for Atomic Scientists, 227.
LEWIS, OSCAR: Wealth Differences in a Mexican Village, 127.
LEWTON, LUCY O.: An Industrial Research Library, 390.
LOWREY, JEANETTE, *et al*: Science in Chicago, 445.

MCATEE, W. L.: The Cats-to-Clover Chain, 241.
MILLER, ERSTON V.: The Story of Ethylene, 335.
MORRISON, JAMES A.: Convention Bureaus in A.A.A.S. Meetings, 306.
MOULTON, BENJAMIN: The Copper Resources of the United States, 143.

NICHOLS, HERBERT B.: Abstracts for the Press, 405.

PARK, ORLANDO: The Pselaphid at Home and Abroad, 27.

RABIN, ALBERT I.: Trends of Vocational Achievement in Mental Disorder, 213.

SAX, KARL: Soviet Science and Political Philosophy, 43.
SCHEFFER, VICTOR B.: The Mystery of the Mima Mounds, 283.
SIMON, COLONEL LESLIE E.: On Instrumentation for Guided-Missile Development, 5.
SMITH, CYRIL STANLEY: Institute for the Study of Metals, 489.
SMITH, MAPHEUS: Populational Characteristics of American Servicemen in World War II, 246.
SMITH, WARREN D.: Another War Casualty, 23.

TELLER, JAMES D.: Louis Agassiz and Men of Letters, 428.
TURNER, C. L.: Viviparity in Teleost Fishes, 508.

WASSON, DONALD: Putting Knowledge to Work, 385.
WEKSTEIN, LOUIS: X-raying the Personality, 133.
WILLARD, BRADFORD: The Geology of Shakespeare, 399.
WILSON, CHARLES MORROW: That More People May Live Better, 199.

WOLFLE, DAEL: Willard Lee Valentine, 91.
WYLIE, CLARENCE R., JR.: Scientific Education for Air Force Officers, 94.

YENAWINE, WAYNE S.: The Air University Library, 395.

ZIRKLE, RAYMOND E.: Institute of Radiobiology and Biophysics, 493.

BOOK REVIEWS

(INDEXED BY REVIEWERS)

ALDRICH, JOHN W.: *Spring in Washington*, by Louis J. Halle, Jr., 259.
AMMONS, R. B.: *Aging Successfully*, by George Lawton, 173; *Mass Persuasion: The Social Psychology of a War Bond Drive*, by Robert K. Merton, 254.

BELL, E. T.: *Science Advances* by J. B. S. Haldane, 433.
BOK, BART J.: *UNESCO: Its Purpose and Its Philosophy*, by Julian Huxley, 172.

CALDER, WILLIAM A.: *Making Your Own Telescope*, by Allyn J. Thompson, 434.
CAMPBELL, JOHN W.: *Atomics for the Millions*, by Maxwell Leigh Eidinoff and Hyman Ruchlis, 438.
CARLSON, A. J.: *On Understanding Science*, by James B. Conant, 258.
COPE, THOMAS D.: *The Evolution of Modern Physics*, by Carl Trueblood Chase, 253.

DANSEREAU, PIERRE: *A Brief Account of the Unknown North Americans*, by Mason Wade, 350.

ELDER, LUCIUS W., JR.: *Modern Chemistry: Some Sketches of Its Historical Development*, by A. J. Berry, 346.

FRAZIER, CHESTER NORTH: *Daniel Coit Gilman: Creator of the American Type of University*, by Abraham Flexner, 80; *Henry Sewall: Physiologist and Physician*, by Gerald B. Webb and Desmond Powell, 80; *Charles-Édouard Brown-Séquard: A Nineteenth Century Neurologist and Endocrinologist*, by J. M. D. Olmstead, 80; *Benjamin Silliman: Pathfinder In American Science*, by John F. Fulton and Elizabeth Thomson, 521.
FRITSCHE, CARL B.: *New Riches from the Soil*, by Wheeler McMillen, 169.

GAMOW, G.: *Meet the Atoms*, by O. R. Frisch, 165.
GARDNER, THOMAS S.: *The Problem of Reducing Vulnerability to Atomic Bombs*, by Ansley J. Coale, 347.
GOLDMARK, PETER C.: *The Future of Television*, by Orrin E. Dunlap, 433.
GRANT, CHAPMAN: *Reptiles and Amphibians of the Northeastern States*, by Roger Conant, 173.

HARRIS, CHAUNCY D.: *The U.S S.R., A Geographical Survey*, by James S. Gregory and D. W. Shave, 261.
HEYL, PAUL R.: *Science Since 1500*, by H. T. Pledge, 83; *The Atomic Story*, by John W. Campbell, 165.
HOEBEL, E. ADAMSON: *The Pueblo Indians of San Ildefonso*, by William Whitman, 3rd, 344.
HUBBS, CARL L.: *This Great and Wide Sea*, by R. E. Coker, 345.

INFELD, LEOPOLD: *The Strange Story of the Quantum*, by Banesh Hoffmann, 437.

JAMIESON, GEORGE S.: *Adventures in Man's First Plastic*, by Nelson S. Knaggs, 440.
JANSSEN, RAYMOND E.: *Ancient Plants and the World They Lived In*, by Henry N. Andrews, Jr., 439.
JELINEK, JAMES J.: *Explaining the Atom*, by Selig Hecht, 165.
JOHNSON, DAVID H.: *Mammals of California*, by Lloyd Glenn Ingles, 256.
JOHNSON, T.: *The Nature and Prevention of the Cereal Rusts as exemplified in the Leaf Rust of Wheat*, by K. Starr Chester, 173.

LAWRENCE, BARBARA: *Mammals of North America*, by Victor H. Cahalane, 441.
LEWIS, OSCAR: *Can Science Save Us?* by George A. Lundberg, 84; *Trinidad Village*, by Melville J. Herskovits and Frances S. Herskovits, 255.

MANN, WILLIAM M.: *The Mammals of Virginia*, by John Wendell Bailey, 256.
MASON, HOWARD S.: *Raw Materials from the Sea*, by E. Frankland Armstrong and L. Mackenzie Miall, 350.
MERRILL, PAUL W.: *Writing Scientific Papers and Reports*, by W. Paul Jones, 254; *Sun, Stand Thou Still*, by Angus Armitage, 439.
MORRISON, B. Y.: *The World Grows Round My Door*, by David Fairchild, 175.

NIELSEN, J. RUD: *The Amazing Electron*, by James I. Shannon, 79.

OEHSER, PAUL H.: *Mammals of Eastern Asia*, by C. H. H. Tate, 256.

PETERSON, ROALD L.: *Life Histories of North American Jays, Crows and Titmice*, by Arthur Cleveland Bent, 85.

RICHEY, FREDERICK D.: *The Wallaces of Iowa*, by Russell Lord, 343.
RIECKEN, F. F.: *Elements of Soil Conservation*, by Hugh Hammond Bennett, 519.
ROLLER, DUANE: *Van Nostrand's Scientific Encyclopedia*, 441.

SMITH, CARL HARRISON, JR.: *German Research in World War II*, by Leslie E. Simon, 261.
SNYDER, MARJORIE B.: *The Origin of Things*, by Julius E. Lips, 437.
SPIER, LESLIE: *Papago Indian Religion*, by Ruth M. Underhill, 170.
STEVENS, O. A.: *Darwin's Finches*, by David Lack, 349.
STROMBERG, GUSTAF: *The Sun's Short Regular Variation and Its Large Effect on Terrestrial Temperatures*, by C. G. Abbot, 176.

TITIEV, MISCHA: *Children of the People*, by Dorothea Leighton and Clyde Kluckhohn, 436.

WADE, J. S.: *Fragments of Entomological History, Part II*, by Herbert Osborn, 259.
WAKEMAN, REGINALD L.: *The New Fibers*, by Joseph V. Sherman and Signe Lidfelt Sherman, 263.
WEBER, ROBERT L.: *Physical Scien e in Art and Industry*, by E. G. Richardson, 435.
WEISS, FRANCIS JOSEPH: *The Life of a Chemist. Memoirs of Vladimir N. Ipatieff*. Zenia Joukoff Eudin, Helen Dwight Fisher, and H. H. Fisher, Eds. V. Haensel and Mis. R. H. Lusher, Translators, 167.
WILCOX, E. V.: *Jesse Buel: Agricultural Reformer*. Harry J. Carman, Ed., 434.
WOOD, LAWRENCE A.: *Buna Rubber. The Birth of an Industry*, by Frank A. Howard, 262.

ZAHNISER, HOWARD: *Handbook of the Trees of the Northern States and Canada East of the Rocky Mountains*, by Romeyn Beck Hough, 347.
ZON, RAPHAEL: *Problems and Progress of Forestry in the United States*, Report of the Joint Committee on Forestry of the National Research Council and the Society of American Foresters, 82.

COMMENTS AND CRITICISMS

BAILY, JOSHUA L., JR.: José Longínos Martinez, 177.
BOLLES, LAURENS C.: Back Into Balance with Nature, 526.

CAMPBELL, F. L.: The Brownstone Tower, 90, 180, 268, 356, 443, 528.
COLLES, WETMORE: Ghost Words, 353.
COPE, THOMAS D.: Jeremiah Dixon? 88.
CREECY, DONALD B., JR.: On the Nature of Entities, 265.

DRUSHEL, S. G.: *Le Problème de L'Utriculaire*, 353.

EWALD, PHILIP: The Nature of Life, 87.

FINK, GEORGE A.: Psychological Phenomenon, 354.

GLEASON, P. R : Copper, 525.
GRIFFIN, HARRIET: Eternal Truths, 354.

HOARD, CHARLES T.: Identifications, 87.

JOHNSON, THORVALDUR: To a *Coprinus*, 266.

KESSLER, M.: A Sad Admission, 88.
KLAUDER, RUDOLPH H.: Is Life a Dream? 266.
KLEIN, M. M.: The Aluminum Rule, 524.
KNOX, HENRY H : Of Chaos and Cosmos, 353.

LEIGHTON, J. A.: Values, 354.

MURDOCK, THOMAS G.: Geology Slighted, 177.
MUSES, CHARLES A.: Errata, 523.

ROTHSCHILD, JAMES B.: Junior Academies of Science, 178.

SCHWARZ, HERBERT, JR.: Nota Bene, 266.
SINCLAIR, JOHN G.: Junior Academies of Science, 178.
SINGLETON, EDWARD B.: Ode to THE SCIENTIFIC MONTHLY, 526.

WEED, MERRILL: Technological Notes, 89, 179, 267, 355, 527.
WHITE, JOHN: Orthodontia, 88.
WILLIAMSON, PAUL B.: Except Ye Utter by the Tongue, 524.

VERSE

DUNCAN, WINIFRED: New England Stones, 371.

GOODMAN, MAE WINKLER: Integral, 154; Nor Gauge the Fruit, 240.

HARWOOD, PAUL D.: A Letter, 334; Ye Shall Know Them by Their Fruits, 394.

KING, THOMSON: Three Questions, 497.

SMYTHE, DANIEL: The Shell, 132.

WYLIE, CLARENCE R., JR.: In Memoriam, 102; Exultation, 342.

SUBJECT INDEX

A.A.A.S. (JOHN M. HUTZEL), 234; (JAMES A. MORRISON), 306.
Agassiz, Louis (JAMES D. TELLER), 428.
Air University (WAYNE S. YENAWINE), 395.
Albatross, the (JOEL W. HEDGPETH), 17.
Alcoholism (JOSEPH HIRSH), 231.
American Foundation for Tropical Medicine, Inc. (CHARLES MORROW WILSON), 199.
Antivivisection (HELEN MACGILL HUGHES), 503.
Ants (CLARENCE HAMILTON KENNEDY), 309.
Army Air Forces Institute of Technology (CLARENCE R. WYLIE, JR.), 94.
Astronomy (J. H. DELLINGER), 115; (REAR ADMIRAL LEO OTIS COLBERT), 372.
Atomic bomb, the (S. H. GOULD), 48.

Biophysics (RAYMOND E. ZIRKLE), 493.
Bureau of Science, Manila (WARREN D. SMITH), 23.

Caldwell, Otis William (FRANCIS D. CURTIS), 495.
Calendar, the (SAMUEL G. BARTON), 408.
Central Radio Propagation Laboratory, National Bureau of Standards (J. H. DELLINGER), 115.
Challenger, the (JOEL W. HEDGPETH), 17.
Chicago scientific institutions (VARIOUS AUTHORS), 445–93.
Coal (P. C. KEITH), 207.
Coast and Geodetic Survey (REAR ADMIRAL LEO OTIS COLBERT), 372.
Conservation of resources (IRA N. GABRIELSON), 181; (A. J. CARLSON), 498.
Copper (BENJAMIN MOULTON), 143.

Earth mounds (VICTOR B. SCHEFFER), 283.
Education (CLARENCE R. WYLIE, JR.), 94; (WAYNE S. YENAWINE), 395.
Einstein, Albert (S. H. GOULD), 48.
Erosion (RAYMOND E. JANSSEN), 103.
Entomology (ORLANDO PARK), 27; (CHARLES HAMILTON KENNEDY), 309.
Ethylene (ERSTON V. MILLER), 335.

Geography (EDWARD B. ESPENSHADE, JR.), 217.
Geology (RAYMOND E. JANSSEN), 103.
Geophysics (J. H. DELLINGER), 115.
Guided missiles (COLONEL LESLIE E. SIMON), 5.

History of science (JOEL W. HEDGPETH), 17; (WARREN D. SMITH), 23; (IRA N. GABRIELSON), 181; (MARGARET DENNY), 415; (J. D. TELLER), 428.
Housing (C. THEODORE LARSON), 295.

Korean Association for the Advancement of Science (FRANK L. EVERSULL), 243.

Law, criminal (LEONARD H. LEVENSON), 227.
Liberia (CHARLES MORROW WILSON), 199.

Map editing (EDWARD B. ESPENSHADE, JR.), 217.
Medicine (CHARLES MORROW WILSON), 199; (JOSEPH HIRSH), 231.
Mental disorder (ALBERT I. RABIN), 213.
Metallurgical Project (SAMUEL K. ALLISON), 482; (CYRIL STANLEY SMITH), 489.
Mima mounds (VICTOR B. SCHEFFER), 283.

Natural gas (P. C. KEITH), 207.
Negro, the (HENRY E. GARRETT), 329.
Nuclear physics and criminal law (LEONARD H. LEVENSON), 227.

Oil (P. C. KEITH), 207.

Parícutin (FRED M. BULLARD), 357.
Philosophy (READ BAIN), 61; (P. W. BRIDGMAN), 148.
Photography (H. H. BLISS), 70.
Political philosophy (KARL SAX), 43.
Pselaphids (ORLANDO PARK), 27.
Psychology (LOUIS WEKSTEIN), 133; (ALBERT I. RABIN), 213; (HENRY E. GARRETT), 329.

Race differences (HENRY E. GARRETT), 329.
Radiobiology (RAYMOND E. ZIRKLE), 493.
Red-clover pollination (W. R. MCATEE), 241.
Relativity (S. H. GOULD), 48.
Rorschach Test (LOUIS WEKSTEIN), 133.
Royal Society of London (MARGARET DENNY), 415.

Science and education (A. J. CARLSON), 498.
Science and government (FELIX S. COHEN), 155.
Science writing (HERBERT B. NICHOLS), 405.
Servicemen in World War II (MAPHEUS SMITH), 246.
Shakespeare, geology in (BRADFORD WILLARD), 399.
Sociology (OSCAR LEWIS), 127; (MAPHEUS SMITH), 246.
Special libraries (DONALD WASSON), 385; (LUCY O. LEWTON), 390; (WAYNE S. YENAWINE), 395.
Sugar research (ROBERT C. HOCKETT), 269.
Sunspots (J. H. DELLINGER), 115.

Teleost fishes (C. L. TURNER), 508.
Tepoztlán, Morelos, Mexico (OSCAR LEWIS), 127.
Termites (CLARENCE HAMILTON KENNEDY), 309.
Thematic Apperception Test (LOUIS WEKSTEIN), 133.
Tides (REAR ADMIRAL LEO OTIS COLBERT), 372.

U.S.S.R. (KARL SAX), 43.

Valentine, Willard Lee (DAEL WOLFLE), 91.
Volcanoes (FRED M. BULLARD), 357.

Date of issue	Date of issue	Date of issue

MGIPC—S5—38 AR/54—7-7-54—7,000.

1. Books are issued for 14 days, beyond
... fine of 15 paise